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ARTS

NEW SPPROACHES IN CONTEMPORARY PAINTING

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Abstract

This article explores new approaches in contemporary painting and analyzes the influence of globalization, technological development, and creative experimentation on modern visual art. The study examines the diversity of techniques, including digital media, mixed materials, installation, and multimedia elements, which have transformed painting into a more interactive and multidimensional form of artistic expression. Particular attention is given to conceptual and abstract tendencies, the role of color and composition, and the synthesis of traditional and modern artistic styles. The article concludes that contemporary painting has become not only an aesthetic phenomenon but also a socio-cultural and philosophical medium reflecting the complexities of modern society.

Keywords: contemporary painting, visual art, multimedia technologies, conceptual art, artistic styles.

Introduction

In the modern era, the art of painting has acquired new forms and content in response to a rapidly changing world. Globalization, technological advancement, and creative freedom have led to the emergence of new approaches in this field. The aim of this article is to examine innovations in contemporary painting, the techniques employed, and the impact of these changes on art. Since the second half of the twentieth century, significant transformations have been observed in painting. Particularly after the 1970s–80s, artists moved beyond the boundaries of classical realism and began to favor more flexible means of expression (Əfəndiyev, R.). During this period, artistic methods such as primitivism, deformation, and stylization became widespread. After the 1990s, political and cultural shifts further influenced artistic practice, contributing to the development of avant-garde and conceptual art movements.

One of the defining features of contemporary painting is the diversity of techniques and materials. Alongside traditional oil painting, artists employ acrylics, collage, installation, and digital media. This diversity not only expands visual expression but also allows artists to present their ideas in more flexible and innovative forms (İsmayılov, C.). In particular, the use of mixed media adds both textural and conceptual depth to artworks.

The application of multimedia technologies also plays a crucial role in this field. In contemporary exhibitions, paintings are often presented in combination with video, light, and sound elements. This approach transforms the traditional notion of static imagery into a dynamic, time-based form of art. As a result, the viewer becomes not just an observer but also a participant in the artwork. Furthermore, the development of digital platforms has expanded the boundaries of painting even further. Artists now present their works not only in galleries but also in virtual environments, reaching wider audiences. Social media and online exhibitions accelerate the dissemination of art and create opportunities for direct interaction with viewers. Consequently, technological and material diversity have turned contemporary painting into a more experimental, interactive, and multidimensional field. This trend is likely to continue, further expanding the creative possibilities for artists.

Another notable aspect of contemporary painting is the synthesis of different styles. Movements such as Realism, Modernism, and Postmodernism are no longer strictly separated; instead, they develop in parallel and interact with one another. As a result of this synthesis, artists preserve traditional methods of representation while enriching them with new aesthetic principles.

Abstract and conceptual approaches are among the most prominent directions in contemporary painting. In these styles, visual representation recedes into the background, while the main focus shifts to the idea, meaning, and the message the artist intends to convey. Artists prioritize content over form, encouraging viewers to think and to establish an intellectual connection with the artwork. In this sense, conceptual art reinterprets traditional aesthetic values and transforms art into a part of philosophical discourse.

Moreover, stylistic diversity in contemporary painting has been further strengthened by the influence of globalization. The combination of elements from different cultures leads to the emergence of hybrid styles. This allows art to become richer and more multilayered, both visually and conceptually. As a result, contemporary painting is not only a means of aesthetic expression but also a carrier of social, cultural, and philosophical ideas (Smith, 2009).

In contemporary visual art, color is no longer limited to a decorative or aesthetic function; it has become a powerful tool of emotional and psychological influence. Artists use color to evoke specific feelings in the viewer and to express internal states and ideas through visual language. The theoretical foundations of this approach were established by Wassily Kandinsky, who argued that color has a direct impact on the human soul (Kandinsky, 1911). Similarly, Johannes Ittensystematically explained color harmony and the

psychological effects of contrasts, making a significant contribution to modern color theory.

From a compositional perspective, contemporary painting is characterized by a shift away from traditional rules toward more свободные and experimental approaches. Classical principles of symmetry and balance are replaced by non-linear structures, asymmetry, and the deliberate arrangement of seemingly random elements. This allows the viewer to perceive the artwork in a more personal and active way. Rudolf Arnheim noted in his theory of visual perception that the arrangement of compositional elements directly influences human psychological responses.

The symbolic meanings of colors have also become more complex and multilayered in contemporary art. The same color can convey different meanings depending on cultural and social contexts. This makes artworks more open to interpretation and encourages multiple readings. Art theorist Arthur Danto considered this multiplicity of meanings a defining feature of postmodern art (Danto, 1997). In addition, the strong use of contrasts—at the level of color, form, and content—has become a key expressive tool in contemporary composition. Sharp color transitions, the interplay of light and shadow, and the combination of different materials create visual dynamism and attract the viewer's attention. James Elkins emphasizes that such experiments expand the boundaries of painting.

In conclusion, in contemporary visual art, color and composition are not merely formal elements but complex means of communication for conveying ideas and emotions. This approach makes artworks more open, multifaceted, and adaptable to individual interpretation. Globalization plays a significant role in the development of contemporary painting, as the interaction of different cultures gives rise to new styles and forms of expression. For example, the synthesis of national traditions with global art has led to the formation of new schools; in Azerbaijani painting, the Absheron school is a notable example.

Contemporary artists are distinguished by their individual styles and thematic diversity. Themes such as memory, the subconscious, and emotional experience occupy an important place in their work. In many cases, the inner world of the individual, psychological states, and social issues come to the forefront. This transforms painting into not only an aesthetic medium but also a socio-philosophical one. Although contemporary painting faces certain challenges—such as the risk of traditional artistic values being overshadowed by rapid technological development—its future remains promising. New technologies and creative approaches continue to enrich this field.

Conclusion

In conclusion, contemporary painting is a constantly evolving and dynamic field. New techniques, styles, and ideas continue to expand its boundaries. Modern approaches make painting more interactive, philosophical, and multidimensional, thereby increasing its role in contemporary society.

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THE ROLE AND IMPORTANCE OF MUSIC LESSONS IN INCLUSIVE EDUCATION

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DOI: 10.5281/zenodo.20309602

Abstract

Inclusive education has become one of the central priorities of modern educational systems, aiming to ensure equal learning opportunities for all students regardless of their physical, cognitive, emotional, or social differences. Within this framework, the role of arts education, particularly music lessons, has gained increasing attention due to its multidimensional impact on student development. This article explores the role and importance of music lessons in inclusive education within general secondary schools.

The study examines how music education contributes to the social integration, emotional well-being, and cognitive development of students in inclusive classrooms. Music, as a universal form of expression, provides opportunities for all learners to participate actively in the learning process, regardless of their individual abilities or limitations.

The research also analyzes the pedagogical approaches and teaching strategies used in inclusive music education. Emphasis is placed on differentiated instruction, student-centered learning, collaborative activities, and the use of multisensory methods. In addition, the role of the teacher is highlighted as a key factor in creating an inclusive and supportive learning environment where every student feels valued and engaged.

The findings indicate that music lessons serve not only as a means of artistic expression but also as a powerful pedagogical tool that supports inclusion, promotes social interaction, and enhances students' overall development. It is concluded that the effective implementation of music education in inclusive settings significantly contributes to building a more equitable and supportive educational environment.

Keywords: inclusive education, music education, general secondary school, inclusive classroom, student development, teaching strategies, social integration, special educational needs, differentiated instruction, educational technologies

In recent decades, inclusive education has emerged as a fundamental principle of modern educational systems worldwide. It is based on the idea that all students, regardless of their individual differences, have the right to access quality education within mainstream school environments. Inclusive education not only promotes equal opportunities but also supports the development of a more just and cohesive society by fostering respect for diversity and mutual understanding among learners.

Within this context, the role of different school subjects in supporting inclusion has become an important area of research. Among these, music education occupies a unique position due to its universal and non-verbal nature. Unlike many academic disciplines that rely heavily on linguistic or cognitive skills, music provides alternative ways of expression and participation, making it particularly suitable for inclusive classrooms.

Music lessons offer a flexible and engaging learning environment where students with diverse abilities can actively participate. Through singing, playing instruments, movement, and listening activities, learners can express themselves, interact with peers, and develop a sense of belonging. These aspects are especially important for students with special educational needs, who may face challenges in traditional academic settings.

Furthermore, music education contributes significantly to students' emotional, social, and cognitive development. It helps reduce anxiety, build self-confidence, and improve communication skills. In inclusive settings, these benefits extend beyond individual development, as music activities encourage cooperation, empathy, and positive social interaction among all students. Therefore, examining the role and importance of music lessons in inclusive education is both relevant and necessary. This article aims to analyze the pedagogical value of music education in inclusive classrooms, focusing on its impact on student development, teaching strategies, and the overall learning environment.

Inclusive education is an educational approach that ensures equal access to learning for all students, regardless of their abilities, disabilities, or social backgrounds. It is based on the principles of equity, participation, and respect for diversity. Instead of separating learners, inclusive education aims to adapt teaching methods and the learning environment to meet the needs of every individual. This requires the use of flexible pedagogical strategies, differentiated instruction, and active student participation. In this context, the teacher plays a crucial role in creating a supportive and inclusive classroom atmosphere where all students feel valued and engaged.

Inclusive education, music lessons occupy a unique and significant place due to their universal and expressive nature. Music allows students to communicate beyond the limitations of language and cognitive ability, providing equal opportunities for participation. Through activities such as singing, rhythm exercises, instrumental performance, and movement, students can interact with one another and develop a sense of belonging. These experiences are particularly beneficial for students with special educational needs, as they support social integration and reduce feelings of isolation.

Moreover, music education contributes greatly to students' emotional and psychological development. It helps reduce anxiety, improve mood, and build self-

confidence. For many learners who struggle in traditional academic subjects, music offers an alternative way to succeed and express themselves. This not only enhances individual development but also strengthens relationships among students, promoting empathy, cooperation, and mutual respect in the classroom. Effective teaching in inclusive music classrooms requires the use of diverse and adaptable instructional strategies. Student-centered learning, collaborative activities, and multisensory approaches are especially important. By combining visual, auditory, and kinesthetic elements, teachers can make learning more accessible and engaging for all students. In this process, the teacher acts not only as an instructor but also as a facilitator and motivator who supports each learner's participation and progress.

In addition, the integration of modern technologies has significantly improved the quality of inclusive music education. Digital tools such as interactive platforms, audio-visual materials, and music applications make lessons more engaging and accessible. These technologies allow students to learn at their own pace and provide alternative ways of participation for those with physical or cognitive challenges. As a result, technology helps remove barriers and enhances inclusivity in the learning process. Another important aspect of inclusive music education is its ability to support communication development among students. Many learners, especially those with speech or language difficulties, find it challenging to express themselves verbally. Music provides an alternative communication channel through rhythm, melody, and sound. Group music-making activities encourage students to listen to each other, respond appropriately, and develop non-verbal communication skills, which are essential in inclusive settings.

In addition, music lessons play a significant role in developing students' self-confidence and motivation. When students successfully participate in musical activities such as singing a song, playing a simple rhythm, or performing in a group, they experience a sense of achievement. This positive reinforcement is particularly important for students with special educational needs, as it increases their willingness to participate in other school activities as well.

Furthermore, inclusive music education supports cultural awareness and diversity appreciation. Through exposure to different musical styles, traditions, and cultural expressions, students learn to respect differences and value diversity. This contributes to the formation of tolerant attitudes and reduces prejudices among learners in the classroom.It is also important to note that inclusive music education encourages cooperative learning. Students often work in groups during music activities, which helps them develop teamwork skills and learn how to support one another. This collaborative environment strengthens peer relationships and improves classroom cohesion, which is a key goal of inclusive education.

Finally, assessment in inclusive music education should be flexible and individualized. Instead of focusing solely on technical performance, teachers should consider students' effort, participation, and progress. Formative assessment methods, such as observation and feedback, are more appropriate in inclusive classrooms as they take into account individual differences and encourage continuous improvement.

Conclusion

In conclusion, music education plays a vital role in the successful implementation of inclusive education in general secondary schools. Its universal and expressive nature makes it an effective tool for engaging students with diverse abilities and backgrounds. Music lessons not only support artistic development but also contribute significantly to students' emotional well-being, social interaction, and cognitive growth.

The inclusive music classroom provides an environment where all students can participate actively, collaborate with peers, and develop a sense of belonging. Through appropriate teaching strategies, such as differentiated instruction, student-centered learning, and multisensory approaches, teachers can ensure that every learner is involved in the educational process. The role of the teacher is therefore essential in creating a supportive and motivating atmosphere that fosters inclusion.The use of modern technologies enhances accessibility and allows for more flexible and individualized learning experiences. These tools help overcome barriers and provide additional opportunities for students with special educational needs to engage in music activities.

Overall, the effective integration of music education into inclusive teaching practices contributes to building a more equitable, supportive, and dynamic learning environment. It can be concluded that music lessons are not only an important component of the curriculum but also a powerful means of promoting inclusion, understanding, and holistic student development.

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THE ROLE OF MUSIC EDUCATION IN THE DEVELOPMENT OF STUDENTS' CREATIVE ABILITIES

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Abstract

The article explores the role of music education in the development of students' creative abilities from pedagogical and psychological perspectives. In modern education systems, the formation of creative skills is considered one of the key priority areas. In this regard, music education serves as an important tool for developing students' aesthetic worldview, emotional intelligence, creative thinking, and individual expression skills. The study analyzes the impact of musical activities on students' cognitive abilities, problem-solving skills, communicative relationships, and the formation of aesthetic appreciation.

The article also discusses the organization of music lessons in schools, the application of interactive teaching methods, and the importance of approaches based on creative activity. It is emphasized that singing, rhythm exercises, music listening, improvisation, and collective musical activities strengthen students' independent thinking and self-expression skills. Music education is evaluated not only as a means of aesthetic upbringing but also as a complex pedagogical process that positively influences students' intellectual and social development.

Keywords: music education, creative abilities, creative thinking, aesthetic education, interactive learning

Introduction

In the modern era, one of the main tasks of the education system is not only to produce students with theoretical knowledge, but also to form individuals who are creative, proactive, aesthetically developed, and capable of adapting to the rapidly changing demands of society. Globalization, the rapid development of information technologies, and the increasing intellectual capacity of society have made the development of creative skills one of the main directions of the educational process. In this regard, arts subjects taught in schools, especially music education, play a significant role in shaping students' creative abilities. Music is one of the most powerful art forms that affects human emotional life, enriches inner feelings and thoughts, and develops aesthetic perception. Therefore, music education is not limited to the acquisition of musical knowledge; it also serves the development of students' creative thinking, imagination, and individual abilities.

The pedagogical importance of music education is related to its influence on the holistic development of personality. Research by psychologists and educators shows that children engaged in musical activities develop attention, memory, logical thinking, emotional stability, and communication skills more effectively. Music activates different functions of the human brain simultaneously, positively influencing both intellectual and emotional development. Especially during school age, involvement in music contributes to the formation of aesthetic taste, strengthens attachment to national and moral values, and increases interest in creativity. Various activities used in music lessons—singing, rhythm exercises, music listening, improvisation, and ensemble performance—develop students' independent thinking skills and expand their self-expression abilities.

Proper organization of music education in schools has a strong impact on the formation of students' personalities. Modern pedagogical approaches emphasize student-centered and interactive methods in music lessons. Unlike traditional teaching methods, creative activity-based approaches ensure active participation of students, increase their interest, and strengthen motivation. In particular, collective musical activities positively influence the development of cooperation, mutual respect, and social communication skills among students. Music also creates emotional comfort, reduces inner tension, and helps stabilize students' psychological state. For this reason, music education in modern schools is considered not only an aesthetic tool but also an important pedagogical and psychological development factor.

In the modern era, technological advancement has created new opportunities in music education. Digital music software, multimedia tools, and interactive learning platforms not only increase students' interest in music but also expand their creative activity opportunities. Modern music teaching is no longer limited to the transfer of theoretical knowledge; it focuses on involving students in practical activities and revealing their individual creative abilities. Therefore, updating the content of music education in schools and organizing it based on modern pedagogical technologies is considered one of the most relevant issues.

Thus, music education is a complex pedagogical process that plays an important role in the development of students' creative abilities, aesthetic and moral upbringing, and emotional and intellectual growth. Through music, students' inner world becomes richer, their individual abilities develop, and their capacity for creative thinking expands. For this reason, increasing the importance of music education in the modern education system and further studying its impact on the formation of creative personality is of particular relevance.

Music education occupies an essential place within the general education system as it contributes to students' aesthetic, emotional, intellectual, and creative development in a holistic manner. In modern

pedagogical theory, music is not viewed solely as an artistic discipline but also as an effective educational tool that shapes personality and supports the development of higher-order thinking skills. The process of engaging with music stimulates students' imagination, enhances their emotional sensitivity, and creates favorable conditions for the formation of creative thinking. In this context, music education serves as a bridge between cognitive learning and emotional experience, allowing students to perceive the world in a more nuanced and expressive way.

Creative ability in education refers to the capacity to generate original ideas, approach problems from multiple perspectives, and find innovative solutions in various situations. Music education plays a particularly important role in developing these abilities because it involves both structured learning and open-ended creative expression. When students engage in musical activities, they do not merely reproduce sounds or melodies; instead, they interpret, analyze, and emotionally experience musical content. This active engagement encourages divergent thinking, which is a key component of creativity. Through rhythm, melody, and harmony, students learn to recognize patterns while simultaneously exploring possibilities beyond fixed structures, which strengthens their cognitive flexibility.

One of the most significant contributions of music education is its impact on emotional development. Music directly influences human emotions, enabling individuals to experience and express complex feelings such as joy, sadness, excitement, and reflection. For students, this emotional engagement is crucial in developing self-awareness and empathy. Emotional intelligence, which is closely linked to creativity, is strengthened through musical experiences that require interpretation and expression. Activities such as singing, listening to music, and improvisation allow students to connect emotionally with content, thereby enhancing their ability to communicate feelings in non-verbal and artistic forms.

Interactive and student-centered teaching methods are particularly effective in music education. Unlike traditional teacher-centered approaches, modern pedagogical strategies emphasize active participation, collaboration, and creativity. Group performances, ensemble work, and improvisational tasks encourage students to cooperate, listen to others, and contribute their own ideas within a shared musical context. These experiences not only improve musical skills but also foster teamwork, communication, and mutual respect. Improvisation, in particular, is a powerful tool for creativity development, as it requires students to make spontaneous decisions, experiment with sounds, and construct original musical expressions without predefined constraints.

Another important aspect of music education is its role in social and cultural development. Through music, students learn to appreciate cultural diversity and understand both national and global musical traditions. Exposure to national music strengthens cultural identity and fosters a sense of belonging, while engagement with world music broadens perspectives and promotes tolerance. This dual influence helps shape well-rounded individuals who are both culturally rooted and globally aware. In this way, music education contributes to the development of socially responsible and culturally sensitive personalities.

The role of the teacher in music education is also crucial. A music teacher is not only a transmitter of knowledge but also a facilitator of creativity and inspiration. Effective teaching requires an understanding of students' individual differences, interests, and abilities. By creating a supportive and open learning environment, teachers can encourage students to express themselves freely and confidently. Motivation, encouragement, and constructive feedback are essential components of this process, as they help students develop self-confidence and a positive attitude toward creative work.

Overall, music education functions as a multidimensional pedagogical system that integrates emotional, cognitive, and social development. Its influence extends beyond artistic skills, contributing significantly to the formation of creative, independent, and socially engaged individuals. By fostering imagination, enhancing emotional intelligence, and developing higher-order thinking skills, music education plays a vital role in preparing students for the complexities of modern life.

Conclusion

Music education plays a significant role in developing students' creative abilities, not only by teaching musical knowledge but also by shaping imagination, independent thinking, emotional intelligence, and self-expression. Regular involvement in musical activities helps improve cognitive skills such as attention, memory, and problem-solving, while also strengthening emotional sensitivity, which is essential for creativity.

Interactive teaching methods like group performance, improvisation, and collaborative tasks increase students' motivation and enhance communication and cooperation skills. The use of modern technologies further supports creative learning by providing new ways for students to express themselves musically.

In addition, music education helps preserve national cultural values while encouraging openness to different cultures. Overall, improving music education through innovative approaches is important for fostering students' creative potential and preparing them for modern society.

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ANALYSIS OF ASSESSMENT MECHANISMS IN MUSIC EDUCATION

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Abstract

Assessment mechanisms in music education play an essential role in the objective and systematic evaluation of students' musical skills, aesthetic perception, and creative potential. In modern pedagogical approaches, assessment is not viewed merely as a tool for measuring outcomes, but also as a formative instrument that regulates the learning process and stimulates student development. In this context, assessment in music education requires a comprehensive evaluation of both theoretical knowledge and practical performance skills.

This article analyzes the main assessment mechanisms used in music education, including formative, summative, and diagnostic assessment approaches. It also examines the methods and criteria used to evaluate students' performance skills, sense of rhythm, music listening abilities, and creative activities. In the context of the integration of digital technologies into modern education, particular attention is given to the application possibilities of electronic assessment tools in music education.

The aim of the study is to analyze the current state of the assessment system in music education, identify its strengths and weaknesses, and propose scientifically grounded recommendations for the implementation of more effective assessment models. The article also reviews the specific features and existing challenges of assessment practices in music teaching in general secondary schools in Azerbaijan.

Keywords: Music Education, Educational Assessment, Digital Assessment Tools, Music, Pedagogy Azerbaijan

Introduction

In the modern education system, assessment is considered one of the essential and integral components of the learning process. In music education in particular, assessment is not limited to measuring students' achieved results; it also serves as a pedagogical tool that directly influences the development of their musical abilities, creative potential, and aesthetic worldview. Since music education is primarily based on practical activity, assessment in this field should not rely on traditional written examinations. Instead, it must be carried out using a wide range of criteria such as performance skills, listening ability, sense of rhythm, and the development of musical thinking. In this regard, the proper organization of assessment mechanisms in music education plays a crucial role in improving the quality of teaching and increasing students' motivation.

In modern pedagogical approaches, assessment is increasingly viewed as a formative process that guides learning and continuously supports student development. At the same time, the integration of digital technologies into education has made it necessary to update assessment methods in music education. Thus, electronic resources and interactive platforms enable more objective and flexible evaluation of students' musical activities. The aim of this article is to analyze the assessment mechanisms used in music education, explore their pedagogical nature, and provide a scientific basis for developing more effective approaches in line with contemporary educational requirements.

Main body

Assessment in music education is a multidimensional process that reflects not only the final learning outcomes but also the dynamics of students' progress throughout the learning journey. Unlike many theoretical subjects, music education requires continuous observation of practical performance, auditory perception, emotional expression, and creative engagement. Therefore, assessment mechanisms in this field must be flexible, criterion-based, and oriented toward both process and result. One of the key theoretical foundations of assessment in music education is the integration of formative and summative approaches. Formative assessment plays a particularly important role, as it allows teachers to monitor students' development during lessons, provide timely feedback, and adjust teaching strategies accordingly. This type of assessment supports individual learning trajectories and helps students gradually improve their musical skills without the pressure of final evaluation alone. Summative assessment, on the other hand, is used to evaluate the overall achievement at the end of a learning period and is typically expressed through grades or performance results. However, in music education, relying solely on summative assessment is insufficient, as it does not fully capture the complexity of musical abilities.

Another important aspect of assessment in music education is the evaluation of practical performance skills. These include singing accuracy, instrumental performance, rhythm perception, intonation control, and expressive interpretation. Since these skills are highly subjective in nature, clear and well-defined criteria are required to ensure fairness and consistency in evaluation. Teachers often use rubrics or descriptive scales that allow them to assess different dimensions of performance separately. For example, a student's performance may be evaluated based on technical accuracy, musical expression, rhythm stability, and stage confidence. Such an approach ensures a more comprehensive understanding of the student's abilities rather than a single generalized score.

Listening skills also represent a significant component of music education assessment. The ability to perceive and analyze musical structures, recognize instruments, distinguish genres, and understand emotional content is essential for developing musical literacy. Assessment of listening skills is often carried out through interactive tasks, such as identifying musical fragments, analyzing compositions, or comparing different performances. These tasks not only measure knowledge but also develop critical thinking and auditory awareness, which are essential for deeper musical understanding.

Creativity is another central dimension in music education that requires specific assessment approaches. Unlike technical skills, creativity cannot be measured through rigid standards; instead, it is evaluated through originality, improvisation, interpretation, and expressive individuality. In classroom practice, creative tasks may include composing simple melodies, improvising rhythmic patterns, or interpreting a musical piece in a personal style. Assessment of such activities is usually qualitative, focusing on the uniqueness of the student's ideas, emotional expression, and artistic engagement rather than technical perfection alone.

In recent years, digital technologies have significantly influenced assessment practices in music education. The use of multimedia tools, audio recording software, and online learning platforms has expanded the possibilities for more objective and transparent evaluation. Teachers can now record student performances, analyze them in detail, and provide more precise feedback. Additionally, digital platforms enable self-assessment and peer assessment, which encourage students to reflect on their own progress and learn from each other. This interactive approach enhances student engagement and promotes a more active learning environment.Despite these advancements, music education assessment still faces several challenges, particularly in general secondary schools. One of the main issues is the lack of standardized assessment criteria, which can lead to subjectivity and inconsistency in grading. Another challenge is the limited training of teachers in modern assessment methods and digital tools. In some cases, insufficient material and technical resources also hinder the effective implementation of innovative assessment practices. Furthermore, the traditional perception of music as a secondary subject in the curriculum may reduce the emphasis placed on systematic evaluation.

In the context of Azerbaijan's general education system, music assessment practices are gradually evolving, but there is still a need for more structured and research-based approaches. Strengthening teacher training programs, developing unified assessment standards, and integrating modern technologies into the classroom could significantly improve the current situation. Moreover, greater attention should be given to balancing theoretical knowledge with practical skills and creative development in assessment design.

Conclusion

The analysis of assessment mechanisms in music education shows that this process is not limited to measuring students' knowledge and skills; it also serves as an important pedagogical tool that guides musical development, increases motivation, and improves the overall quality of teaching. Modern approaches view assessment not as a static system of outcome measurement, but as a continuous and development-oriented process closely integrated with instruction. In this regard, assessment in music education should combine both formative and summative elements and comprehensively cover various competencies such as performance, listening, rhythm, and creativity.

The analysis indicates that a well-designed assessment system supports students' individual development, helps them better understand their own potential, and strengthens their interest in music. At the same time, ensuring objectivity in assessment requires clearly defined criteria, the application of standardized rubrics, and the improvement of teachers' professional competencies in this field. The integration of digital technologies into the learning process further enables assessment to become more flexible, transparent, and multidimensional, while also enhancing students' self-assessment and reflection skills.

Addressing existing challenges—such as the lack of methodological resources, the absence of unified assessment standards, and limited technical infrastructure—is essential for improving the quality of music education. Overall, the development of effective assessment mechanisms in music education contributes not only to better learning outcomes but also to the formation of creative individuals and the broader development of musical culture.

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HARMONY OF NATIONAL MOTIFS IN VISUAL ARTS LESSONS AND ITS PEDAGOGICAL SIGNIFICANCE

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Abstract

This article examines the formation of harmony in national motifs within visual arts lessons and its pedagogical significance. The integration of national ornaments and cultural elements into the teaching process positively influences the development of students' aesthetic taste, creative abilities, and sense of national identity. At the same time, the systematic and purposeful application of national motifs increases students' interest in lessons, expands their individual expressive capacities, and fosters creative thinking. The adaptation of selected examples by the teacher to students' age characteristics, their enrichment through various artistic techniques, and their presentation via interactive methods enhance the quality of the learning process. Furthermore, the use of visual materials based on national heritage strengthens students' respect for cultural values and deepens their connection to their national roots. The study shows that the harmonious integration of national motifs in visual arts education contributes not only to the development of artistic skills but also to the formation of students' personality and their adaptation to the social and cultural environment. In this regard, a pedagogical approach based on national motifs can be considered a relevant and promising direction in modern education.

Keywords: visual arts education, national motifs, aesthetic education, cultural heritage, art pedagogy.

Introduction

In the modern education system, the preservation and transmission of national-spiritual values to future generations is one of the main priorities. In this context, visual arts lessons are of particular importance. The harmonious application of national motifs serves the aesthetic and cultural development of students. The aim of this study is to determine the pedagogical significance of the harmony of national motifs in visual arts lessons. To achieve this aim, methods of analysis, comparison, and observation were employed.

National motifs are formed as an artistic expression of a people's history, culture, and aesthetic worldview. In Azerbaijani visual art, these motifs are particularly reflected in carpet weaving, miniature art, and decorative-applied arts (Efendiyev, 2001). Ornaments, symbols, and color harmony are key carriers of national culture. These elements perform not only an aesthetic function but also convey semantic meaning (Bunyadov, 2005). Therefore, their use in the educational process plays an important role in the formation of students' cultural awareness.

The application of national motifs in visual arts lessons can be implemented through various methods. These include the construction of decorative compositions, the development of ornaments, and the modern interpretation of national patterns. During the application of these methods, the teacher should simultaneously present both traditional and innovative approaches, developing students' ability to conduct comparative analysis. For example, alongside teaching classical national ornaments, students may be given tasks to create new design samples using these motifs.

Within the curriculum framework, the integration of these motifs stimulates students' creative activity and develops their independent thinking skills (Vygotsky, 1978). This process is of particular importance in ensuring students' active participation through project-based learning, group work, and practical exercises. Such an approach not only strengthens students' theoretical knowledge but also their practical skills, while revealing their individual creative potential.

At the same time, this approach increases students' interest in national heritage and positively influences the formation of their cultural identity. Through national motifs, students gain a deeper understanding of the richness of folk art and recognize the necessity of preserving this heritage and transmitting it to future generations. Consequently, the purposeful and creative application of national motifs in visual arts education comprehensively contributes to both the aesthetic and intellectual development of students and enhances the effectiveness of the teaching process.

The harmony of national motifs is based on the coherence of color, form, and compositional elements. A harmonious composition helps to develop students' aesthetic taste. The appropriate selection of colors and the balanced arrangement of ornaments ensure the integrity of the visual artwork (Arnheim, 1974). This process develops students' visual analysis and artistic thinking abilities.

The use of national motifs in teaching fosters the development of national identity and patriotism in students. It strengthens their attachment to cultural heritage and broadens their aesthetic worldview. The teacher's proper methodological approach plays a decisive role in this process. The teacher should organize a creative learning environment by

considering students' individual characteristics (Dewey, 1934). This approach increases the effectiveness of instruction.

Conclusion

The conducted analysis shows that the harmony of national motifs in visual arts lessons has a positive impact on students' overall development. This approach enhances their aesthetic taste, creative abilities, and national consciousness. At the same time, students' observation skills, imagination, and artistic expression become more developed, and their individual creative style begins to take shape. This process also supports their emotional and intellectual development, increasing their sensitivity to art and encouraging more creative engagement with their environment. Working with national motifs strengthens students' research interest, motivating them to explore various examples of folk art and generate new ideas inspired by this heritage. As a result, it is recommended that teachers apply national motifs more extensively in the teaching process and strengthen the harmonic approach. This can be achieved by improving teachers' methodological training, enriching teaching materials with national-cultural elements, and using modern educational technologies. Furthermore, increasing the use of interactive and creative tasks, expanding students' opportunities for independent expression, and considering their individual characteristics will further enhance the effectiveness of instruction. Thus, visual arts education based on the harmonious application of national motifs serves not only the development of artistic skills but also acts as an important pedagogical direction contributing to the preservation and transmission of national-spiritual values to future generations.

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BIOLOGICAL SCIENCES

PLANTS AS AN İNTERESTİNG OBJECT FOR SCİENCE AND PRODUCTİON

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Abstract
This article examines plants as important objects of scientific research and practical production. The study highlights the ecological, biological, agricultural, and economic significance of plants, emphasizing their essential role in oxygen production, food chains, climate regulation, and sustainable development. Special attention is given to the importance of plants in biotechnology, genetics, ecosystem stability, and environmental protection. The article also discusses the relevance of plant studies in addressing global ecological challenges, biodiversity conservation, and the impact of invasive species. It is concluded that comprehensive plant research remains highly important for modern science and society.

Keywords: plants, biodiversity, sustainable development, ecology, plant science.

As is known, all living things are constantly in food and energy exchange with the environment in order to continue their life activities and participate in the ecological functions they perform in nature, and this is characteristic of both producers (plants), consumers (animals), and reducers (fungi and bacteria) in an ecological sense. However, the dependence of consumers, as well as reducers, on the environment is a more sensitive feature than that of producers, since both of the latter, namely fungi and animals, are heterotrophic in terms of nutrition[158], that is, since they cannot carry out the photosynthesis process, their need for organic matter, as well as oxygen, is met by other sources, primarily plants. Since plants play an important role in providing food for most living things, their comprehensive study has always been relevant and continues to maintain this status in full force today. This allows us to state this in the following general terms as a result of the analysis of the literature data:

People's ideas about plants are based on a wide spectrum of their activities and cover, or rather touch, all areas of human life. Because from the moment human civilization arose and began to develop, it has depended on the management of plants, and in a number of cases this issue failed due to the lack of necessary knowledge. Nevertheless, throughout history, plants have been collected, become objects of trade, selectively adapted to new habitats and propagated in order to obtain individuals with new characteristics. As a logical consequence of this, plants have been manipulated for various (food, feed, medical, technical, etc.) purposes, including aesthetic (decorative properties), and this situation continues to this day. Moreover, modern civilization is based on the more efficient and sustainable use of the biological and physical resources of plants in accordance with the principles of sustainable development. Because even today, our understanding of the environment is still incomplete and there are many issues that need to be clarified, which cannot be solved without a comprehensive study of plants. The importance of this situation is more pronounced in the current global problems in the world, as well as in the modern level of development of science and technology.

It is known that most living things on Earth cannot live without atmospheric air, that is, oxygen, that is, they are aerobic. The role of plants, as well as some microorganisms, is indispensable in meeting the needs of living things in this regard. Thus, only plants and some microorganisms meet the needs of living things for oxygen and organic matter by converting solar energy into chemical energy. Their role does not end there, and the mentioned group of living things plays an important role in regulating the chemical and biological state of the climate, soil and water, is the source of minerals (for example, coal) that we are depleting today, that is, it is an easily accessible renewable energy source for the future. In addition, the irreplaceable role of plants, as well as photosynthetic bacteria, in regulating the substances occurring in the biosphere, primarily the carbon cycle, in making atmospheric nitrogen, which is in a symbiotic relationship with microorganisms and inert, usable by all living things, in preventing soil erosion and water pollution, in improving the ecological aspects of open and closed environments where people operate, etc. is a reality that no one doubts today. It is no coincidence that in modern times, plants are considered to be one of the integral components of the “One Health” strategy. Nevertheless, the negative consequences of human industrial activity, namely the increasing burden of anthropogenic impact on the environment, the increasing number of world population against the background of these events, and other consequences of the use of nature, can change the buffer system of natural processes regulating the global climate to such an extent that the global climate change that humanity is already experiencing today can be an example of this. The further development of the Earth also depends on the results that people will achieve in a more intelligent and efficient use of plant life. It should be noted that plants differ from other living things in a number of qualities, which is the basis of scientific and practical

interest in them. It would be logical to substantiate this idea by touching on some of these differences.

Firstly, only a few phytohormones are required for the transformation of undifferentiated, i.e. somatic cells of plants into mature individuals, and it is possible to regenerate an entire organism from cells of vegetative (leaf and root) organs. An analogous feature is not found in animals.

Secondly, as mentioned, plants are practically the main and only source of organic substances on Earth, primarily oxygen. This is due to the presence of chloroplasts capable of collecting solar energy in plants, the synthesis of 20 essential amino acids necessary for the formation of proteins, including 9 that are not produced by humans (valine, tryptophan and phenylalanine, leucine, isoleucine, lysine, methionine and threonine), and the ability to fix nitrogen in the atmosphere, which living things in the atmosphere, as well as plants themselves, cannot use.

Thirdly, despite the fact that plants do not have the main organ system, that is, the nervous system, which is found in animals, their physiological properties are that they react to what is happening in the environment. In addition to the immune system, plants have an induction mechanism that provides resistance to diseases caused by pathogens and the toxins they synthesize.

Fourthly, primitive and higher plants form the initial link in the food chain in terrestrial and aquatic systems. For this reason, plants occupy a central place in agriculture, and together with microorganisms and domestic animals, they can play the role of a source of raw materials for human nutrition, for people for various purposes, for example, clothing, construction materials, etc. In addition, the application of basic information about plants, for example, the study of plant nutrient requirements allows for the management of soil fertility, and allows us to confidently state that plants still have the potential to solve existing problems in the modern era, and therefore their research in various aspects is still relevant today.

Fifth, although the science of ecology has made great progress in terms of understanding the dynamics of ecosystems and the processes that regulate their trophic structure, systematic differences between ecosystems still remain [256], which leads to the fact that controversial issues still remain. The elimination of these can only be achieved through a comprehensive study of the plants in the ecosystem. By the way, there are no studies in the Republic of Azerbaijan aimed at studying biodiversity at the ecosystem level.

In addition to the above, as a result of the study of plants, a number of issues that have played an important role in the development of modern biology and are still based on it, such as Mendel's laws that form the basis of genetics (experiments conducted on peas), the phytochrome phenomenon, the transposition of genetic elements (maize), the protein nature of enzymes, etc. has been clarified, that is, plants are also used as model organisms, which allows us to confidently state once again that plants are interesting and relevant objects of research of any aspect and that it is necessary to conduct research in these directions.

In addition, the study of plants is also related to another point, which is related to the occurrence of invasions. Thus, as a result of a number of studies conducted, it becomes clear that thousands of local species have disappeared due to invasive, that is, introduced species[185]. Preventing this is important both in terms of the Rio de Janeiro Convention on Biodiversity and in terms of solving the problems arising from globalization. This issue, namely the study of plants in the conditions of Azerbaijan, is also important from another point, since the fact that a certain part of its territory has been under occupation for 30 years, the ecological terror carried out by the occupiers, as well as the fact that most of the water used for irrigation of agricultural crops is carried out at the expense of transboundary rivers, also allows us to confidently state this.

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REVIEW OF SIGNALING PATHWAYS AND MORPHOLOGICAL CHANGES OF PROGRAMMED CELL DEATH – APOPTOSIS

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ОБЗОР СИГНАЛЬНЫХ ПУТЕЙ И МОРФОЛОГИЧЕСКИХ ИЗМЕНЕНИЙ ЗАПРОГРАММИРОВАННОЙ КЛЕТОЧНОЙ СМЕРТИ – АПОПТОЗА

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Abstract
This article explores the molecular mechanisms underlying the regulation of apoptosis for the development of targeted therapeutic strategies. Modulation of apoptotic pathways holds enormous potential in cancer treatment, where stimulating apoptosis in malignant cells can lead to tumor regression. Furthermore, this review article examines various types of cell death, highlighting important targets in the apoptotic pathway for potential therapeutic interventions in human diseases.

Аннотация
Данная статья посвящена изучению молекулярных механизмов, лежащих в основе регуляции апоптоза, для разработки целенаправленных терапевтических стратегий. Модуляция апоптотических путей обладает огромным потенциалом в лечении рака, где стимулирование апоптоза в злокачественных клетках может привести к регрессии опухоли. Кроме того, в этой обзорной статье рассматриваются различные виды клеточной смерти, выделяя важные мишени в апоптотическом пути для возможных терапевтических вмешательств при заболеваниях человека.

Keywords: apoptosis, mitochondria, cell death, embryogenesis, necrosis.
Ключевые слова: апоптоз, митохондрии, клеточная смерть, эмбриогенез, некроз.

Введение. Формирование и поддержание тканей, а также общее состояние многоклеточных организмов зависят от важного и строго регулируемого процесса - клеточной смерти. Он организует как пролиферацию, так и элиминацию клеток, обеспечивая физиологический баланс во взрослых организмах. Этот сложный механизм действует на критических стадиях, таких как метаморфоз, эмбриогенез и обновление тканей, а также в ответ на патогенные угрозы [1]. Двумя основными механизмами клеточной смерти являются запрограммированная клеточная смерть (апоптоз) и некроз.

Апоптоз, регулируемый сигналами, включает саморазрушение в ответ на внешние или внутренние сигналы, играя ключевую роль в поддержании тканевого гомеостаза путем удаления ненужных или поврежденных клеток. В то время как апоптоз строго регулируется и включает ключевые молекулы, такие как каспазы, Bcl-2, Bax и Bak, некроз представляет собой хаотичную и неконтролируемую форму разрушения клеток, связанную с патологическими реакциями после серьезного повреждения клеток [2]. Аутофагическая клеточная смерть и некроптоз представляют собой дополнительные запрограммированные формы, способствующие пониманию этих сложных процессов.

В апоптозе участвуют несколько сигнальных путей, среди которых основными являются *внутренний* (митохондриальный) и *внешний* (рецептор смерти). Инициирующие каспазы (каспаза-8 и -9) и исполнительные каспазы (каспаза-3, -6 и -7) играют ключевую роль в апоптотических сигнальных каскадах. Внешний путь инициируется лигандами, такими как фактор некроза опухоли (ФНО), образуя индуцирующий смерть сигнальный комплекс (DISC), который активирует каспазу-8 и нижележащие каспазы [3].

Апоптоз поддерживает общее здоровье человека, устраняя клетки, непригодные для выполнения определенных функций. Понимание молекулярных механизмов апоптоза пролило свет на фундаментальные биологические процессы, открывая путь для новых терапевтических стратегий [4]. Воздействие на апоптотические пути активно изучается для лечения таких заболеваний, как рак, нейродегенеративные расстройства и аутоиммунные заболевания. Модуляция молекул и

путей, связанных с апоптозом, имеет потенциал для инновационных методов лечения [5].

Первичная клеточная смерть. Апоптоз и некроз. Клеточная смерть - это фундаментальный процесс, имеющий решающее значение для развития, поддержания тканей, и общего здоровья многоклеточных организмов. Этот процесс включает в себя как пролиферацию, так и Гибель клеток, имеющий решающее значение для развития, поддержания тканей и общего здоровья многоклеточных организмов. Кроме пролиферации клеток, он включает в себя и элиминацию для поддержания физиологического баланса в организмах взрослых людей. Этот процесс служит для удаления нежелательных клеток во время метаморфоза, эмбриогенеза и обновления тканей, а также в ответ на патогенные угрозы. Существуют два основных механизма гибели клеток: программированная гибель клеток – *апоптоз*, и *некроз* [6].

Запрограммированная гибель клеток, или ***апоптоз***, - это генетически регулируемый процесс, при котором клетки подвергаются саморазрушению в ответ на определенные сигналы. Эти сигналы могут быть внеклеточными или внутриклеточными, направляемыми окружающей средой клетки или внутренними факторами, которые включают Bax, Bak и цитохром ***c*** [7]. Апоптоз играет жизненно важную роль в поддержании тканевого гомеостаза, устраняя ненужные или поврежденные клетки и регулируя численность клеток в многоклеточных организмах [8]. Экзогенные агенты, включая радиацию, физические травмы, вирусы и бактериальные токсины, а также эндогенные агенты, такие как TRAIL-R4, запускают запрограммированную гибель клеток в физиологических условиях.

Хотя апоптоз ассоциируется с запрограммированной клеточной смертью, недавние исследования показали, что существуют и неапоптотические формы запрограммированной клеточной смерти, что указывает на то, что запрограммированная клеточная смерть и апоптоз не являются синонимами [9]. Термин «апоптоз» был впервые предложен Керром и др. (1972) для описания особого морфологического паттерна клеточной смерти. Апоптоз - это строго регулируемый процесс, в котором каспазы-3, -7 и -9 выступают в роли исполнителей, а bcl-2, Bax и Bak играют роль регуляторных молекул. С биохимической точки зрения, апоптотическая гибель клеток включает инверсию фосфатидилсерина и активацию каспаз, которые способствуют гибели клеток [5,10].

Апоптоз строго регулируется, тогда как некроз, напротив, представляет собой хаотичную и неконтролируемую форму разрушения клеток. Обычно он включает увеличение клеток, разрушение мембран и вытекание клеточного материала во внеклеточное пространство. Как правило, это патологическая реакция, возникающая после серьезного повреждения клеток. Высвободившийся клеточный материал может быть распознан иммунной системой как чужеродный, что приводит к воспалительной реакции. Некроз, традиционно считающийся случайным и неконтролируемым процессом, запускаемым специфическими стимулами, такими как токсическая травма или физическое повреждение, морфологически характеризуется набуханием цитоплазмы и органелл, нарушением плазматической мембраны и лизисом клеток [11].

Некроз не является полностью неупорядоченным процессом; такие факторы, как TNFα, которые, как сообщается, являются мощными индукторами апоптоза в различных типах клеток, также потенциально могут вызывать некроз в клеточной линии мышиной фибросаркомы L929. Некроз может привести к хроническому воспалению, которое может способствовать пролиферации опухоли [12]. Однако недавние исследования показывают, что некроз также может быть запрограммированным в природе. Запрограммированный некроз наблюдался в определенных условиях, когда апоптоз химически или генетически блокируется или подавляется. Было показано, что некоторые антиапоптотические белки семейства Bcl-2 ингибируют как апоптотические, так и некротические пути [13]. Кроме того, истощение внутриклеточного уровня АТФ может вызвать открытие пор митохондриальной мембраны, известных как митохондриальные переходные поры (MPTP), которые могут трансформировать апоптотическое и некротическое событие, что указывает на возможное взаимодействие между этими путями. Однако интерес к неапоптотическим формам запрограммированной клеточной смерти, таким как аутофагия, некроптоз и апоптозоподобная запрограммированная клеточная смерть, возрастает в связи с растущим пониманием этих процессов [14].

Сигнальные пути апоптоза. Как уже сообщалось, апоптоз - это строго регулируемый процесс, необходимый для поддержания гомеостаза тканей и удаления нежелательных или поврежденных клеток в многоклеточных организмах. В апоптозе участвуют несколько сигнальных путей, причем двумя основными являются *внутренний* (митохондриальный) путь и *внешний* (путь рецепторов смерти). Понимание механизмов апоптоза имеет важное значение для развития заболеваний, вызванных нарушением апоптоза, что способствует разработке таргетных препаратов для конкретных апоптотических путей или генов [15].

Внутренний путь апоптоза, опосредованный митохондриальным путем, работает строго регулируемым образом, реагируя на различные клеточные стрессы, которые приводят к высвобождению проапоптотических факторов. Поддержание тонкого баланса между про- и антиапоптотическими членами семейства Bcl-2 имеет решающее значение для регулирования целостности митохондрий и определения клеточной судьбы. Внутренний путь завершается

разрушением клетки, при этом апоптотические клетки претерпевают изменения на своей клеточной поверхности, что облегчает их распознавание и поглощение фагоцитами [16].

Сигнальный путь митоген-активированной протеинкиназы (MAPK) играет сложную и контекстно-зависимую роль в регуляции апоптоза, влияя как на проапоптотические, так и на антиапоптотические процессы. Путь MAPK представляет собой консервативный внутриклеточный сигнальный каскад, который реагирует на различные внеклеточные стимулы, включая факторы роста, сигналы стресса, и цитокины. Три основных подсемейства MAPK, участвующих в регуляции апоптоза, - это внеклеточные сигнально-регулируемые киназы (ERK), c-Jun N-концевые киназы (JNK) и p38 MAPK [26]. В определенных контекстах активация ERK способствует выживанию клеток и ингибирует апоптоз [17]. Это может происходить за счет повышения уровня антиапоптотических белков, таких как члены семейства Bcl-2, или ингибирования проапоптотических факторов. Сигнализация JNK может либо способствовать выживанию клеток, либо индуцировать апоптоз, в зависимости от клеточного контекста и стимулов. Активация JNK часто связана с апоптозом, индуцированным стрессом. JNK могут фосфорилировать и активировать проапоптотические члены семейства Bcl-2, нарушать целостность митохондриальной мембраны и стимулировать высвобождение проапоптотических факторов [17,18].

Сигнализация JAK-STAT. Активация пути JAK-STAT происходит при связывании лиганда, включая цитокины, факторы роста или гормоны, с рецепторами клеточной поверхности. Эти рецепторы ассоциируются с янускиназами (JAK), которые активируются при связывании лиганда. Эта активация приводит к конформационным изменениям в рецепторе, впоследствии активируя связанные с ним JAK. Фосфорилирование тирозиновых остатков на рецепторе создает сайты связывания для белков-трансдукторов и активаторов транскрипции (STAT). После рекрутирования белки STAT подвергаются фосфорилированию JAK, образуя димеры, которые перемещаются в ядро.

Внутри ядра димеры STAT связываются со специфическими последовательностями ДНК, регулируя транскрипцию целевых генов, участвующих в выживании, пролиферации, дифференцировке и апоптозе клеток [19]. Путь JAK-STAT оказывает двойное воздействие на апоптоз: некоторые регулируемые STAT гены, включая членов семейства Bcl-2, ингибируют апоптоз, предотвращая высвобождение митохондриального цитохрома ***c***. И наоборот, другие целевые гены могут способствовать апоптозу, активируя проапоптотические пути. Тонкий баланс между антиапоптотическими и проапоптотическими сигналами имеет решающее значение в определении судьбы клетки. Дисрегуляция пути JAK-STAT связана с такими заболеваниями, как рак, где аберрантные сигналы выживания могут препятствовать апоптозу [20].

STAT3 - это фактор транскрипции, играющий решающую роль в пути JAK-STAT, участвующий в клеточных процессах, таких как выживание, пролиферация и дифференцировка. STAT3 в первую очередь выполняет антиапоптотическую функцию, повышая экспрессию антиапоптотических генов, таких как Bcl-2 и Bcl-xL. Эти белки ингибируют внутренний апоптотический путь, предотвращая высвобождение цитохрома ***c*** из митохондрий. Более того, STAT3 может прямо или косвенно ингибировать проапоптотические факторы, подавляя транскрипцию проапоптотических членов семейства Bcl-2 или ингибируя активацию каспаз [21].

STAT3 также способствует защите митохондрий, что имеет решающее значение для предотвращения инициации апоптоза. Он взаимодействует с различными сигнальными путями, такими как PI3K-Akt, косвенно влияя на апоптоз. Аберрантная активация STAT3 часто встречается при раке, способствуя выживанию клеток и устойчивости к апоптозу. Роль STAT3 в апоптозе зависит от контекста, поскольку он может либо способствовать выживанию клеток, либо вносить вклад в проапоптотические сигналы в зависимости от конкретных условий или типов клеток [22].

Помимо внешнего и внутреннего путей, существуют менее известные пути активации каспаз, включая участие каспазы-12 или каспазы-2, которая является ферментом, участвующим в стресс-индуцированном пути апоптоза эндоплазматического ретикулума (ЭР). Нарушение регуляции каспазы-12 связано с хроническими заболеваниями, такими как рак. Другой, менее известный путь — это путь перфорин/гранзим, который индуцирует апоптоз через гранзим А или гранзим В. Гранзим А и гранзим В оба запускают апоптоз в клетках-мишенях, хотя и по разным механизмам.

Ключевыми регуляторными белками как во внутреннем, так и во внешнем путях являются каспазы. Каспазы млекопитающих подразделяются на три группы в зависимости от их специфических функций: пути развития, воспаления и апоптоза. Каспазы могут быть классифицированы как *инициаторные* (каспазы-8 и -9) и *эффекторные* или исполнительные каспазы (каспазы 3, -6 и -7) в зависимости от их положения в каскадах апоптотических сигналов [23]. Инициаторные каспазы активируются путем ауторасщепления и впоследствии расщепляют и активируют нижележащие «исполнительные» каспазы, что приводит к протеолитическому разрушению клетки. Понимание апоптотических путей имеет жизненно важное значение для расшифровки патогенеза заболеваний и продвижения разработки лекарств, нацеленных на конкретные апоптотические механизмы.

Роль апоптоза в поддержании здоровья человека. Апоптоз поддерживает общее здоровье человека, устраняя клетки, которые не в состоянии выполнять свою специфическую функцию. Нарушение регуляции апоптоза связано с широким спектром заболеваний, включая рак, нейродегенеративные расстройства, аутоиммунные заболевания и сердечно-сосудистые заболевания [24]. Понимание молекулярных механизмов, лежащих в основе апоптоза, не только пролило свет на фундаментальные биологические процессы, но и открыло путь для разработки новых терапевтических стратегий. Глубокое понимание апоптоза открыло новые возможности для терапевтических вмешательств.

Воздействие на апоптотические пути обладает огромным потенциалом для лечения различных заболеваний. Активно изучаются стратегии, направленные на индукцию апоптоза в раковых клетках или предотвращение чрезмерной гибели клеток при нейродегенеративных расстройствах. Кроме того, модуляция молекул и путей, связанных с апоптозом, может привести к разработке инновационных методов лечения состояний, в которых нарушение регуляции апоптоза играет важную роль [25].

Заключение и выводы. Как видно из обзора, исследования апоптоза, важной клеточной активности, выявили сложные молекулярные процессы, управляющие выживанием и гибелью клеток. За прошедшие годы наше понимание апоптоза значительно расширилось, охватив множество типов и путей, которые координируют тонко настроенное равновесие в многоклеточных организмах. События апоптоза высокоорганизованы и включают в себя последовательность синхронизированных процессов, начиная с сигналов инициации и заканчивая фазой исполнения, в которой клетка подвергается регулируемому разрушению. Эта запланированная гибель клетки необходима не только для нормального роста и тканевого гомеостаза, но и для устранения поврежденных или потенциально вредных клеток. Однако нарушение регуляции апоптоза было связано с различными заболеваниями. В медицинских исследованиях возможность воздействия на апоптоз для лечения заболеваний, связанных с ним, была определена как потенциальная мишень.

Понимание апоптоза имеет решающее значение в контексте регенерации тканей и заживления ран. Будущие исследования могут быть сосредоточены на том, как апоптоз влияет на ремоделирование и регенерацию тканей. для улучшения регенеративных подходов при различных травмах и заболеваниях.

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CHEMICAL SCIENCES

STUDY OF THE CHEMICAL COMPOSITION OF THE PLANT FERULA LIPSKYI KOROVIN USING HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

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Abstract

This article presents the results of a study of the amino acid composition of the roots of Ferula lipskyi, a plant native to the Fergana Valley. Plants of the genus Ferula are a valuable source of natural biologically active substances and are widely used in folk and traditional medicine due to the presence of essential oils, resins, coumarins, flavonoids, terpenoids, amino acids, and mineral compounds. The aim of the study was to qualitatively and quantitatively determine the amino acid composition of Ferula lipskyi roots. The analysis was performed by high-performance liquid chromatography with a fluorescence detector on an Agilent 1260 II Infinity system using standard amino acid samples. Serine, glycine, threonine, arginine, alanine, lysine, valine, methionine, phenylalanine, isoleucine, and proline were identified in the sample. The highest content was found for threonine—0.98 mg/g, glycine—0.79 mg/g, and lysine—0.53 mg/g. Asparagine, glutamine, histidine, glutamate, and tryptophan were not detected in the test sample. The obtained data demonstrate the specificity of the amino acid profile of Ferula lipskyi and confirm the promise of further phytochemical and pharmacological study of this plant as a potential source of natural biologically active compounds for the pharmaceutical and food industries..

Keywords: *Ferula lipskyi,* genus Ferula, amino acid composition, plant roots, biologically active substances, high-performance liquid chromatography, fluorescence detector, threonine, glycine, lysine.

With the development of medicine, the delivery of medications to patients is becoming increasingly important. The majority of drugs used in medical practice are biologically active substances isolated from plant components. Plants of the genus Ferula are a valuable source of natural biologically active substances and are widespread in the arid and mountainous regions of Central Asia. Representatives of this genus contain essential oils, resins, coumarins, flavonoids, terpenoids, amino acids, and minerals. Due to their rich chemical composition, Ferula plants exhibit anti-inflammatory, antimicrobial, antioxidant, antispasmodic, and restorative properties. In folk and traditional medicine, they are used to treat various diseases and are also considered promising raw materials for the pharmaceutical, food, and agricultural industries. The chemical composition of Ferula plants depends on the species, growing conditions, climate, soil composition, and stage of plant development, necessitating their comprehensive phytochemical and pharmacological studies. [1,2]. Objective: To study the amino acid composition of the root parts of Ferula lipskyi, a plant native to the Fergana Valley.

About the plant: Ferula lipskyi is a large perennial plant, typically reaching a height of 1.5–2.5 meters. It is characterized by a strong putrid odor. Rhizome: thick, large, often coarse. It is highly branched underground. It secretes a yellowish milky sap (rich in substances with anti-inflammatory properties). Stem: erect, large, hollow, smooth or slightly inflamed. It reappears annually. Leaves: large, intricately divided into four or five parts. The lobes are small and needle-like. The leaf blades have an expanded, cap-shaped sheath. Flowers: small, yellowish. Arranged in complex umbel-shaped (zonal) inflorescences. The flowers are bisexual. Fruit: A mericarp (split fruit) dividing into two wing-shaped parts. Each part has five distinct marginal lines. The fruit turns yellow-orange when ripe. Distribution and ecology: Distribution: Central Asia, especially the foothills and mountains of Uzbekistan, Tajikistan, and Kazakhstan. Habitat: Dry valleys, rocky and sandy soils, steppes, and slopes. Growing season: Grows in spring; fruits ripen in late summer.

Materials and methods

The root parts of Ferula lipskyi, collected in the Fergana district of the Fergana region in May 2025, were used as the test sample. The plant sample was analyzed for qualitative and quantitative amino acid parameters using standard samples supplied by Sigma Aldrich (Germany). The determination was carried out using a fluorescence detector (FLD) installed on an Agilent 1260 II Infinity liquid chromatography system, manufactured by Agilent Technologies, USA. A

Poroshell 120 EC-C18 column (150 mm × 4.6 mm × 4 µm), manufactured in the USA, was used as the stationary phase. Pre-column derivatization was performed in an automatic programmable mode. For amino acid analysis, the following mobile phases were used: phase A — a solution of sodium dihydrogen phosphate (40 mM), pH 7.8, and phase B — a mixture of acetonitrile, methanol, and water (in a ratio of 45:45:10), using a gradient mode.

Time | Phase A % (sodium dihydrogen phosphate solution, 40 mM, pH 7.8) | Phase B% (acetonitrile: methanol: water = 45:45:10).

The flow rate was 1 ml/min, the thermostat temperature was 40°C, the injected sample volume was 5 µl, the analysis was carried out for 30 minutes, and the following chromatograms were obtained

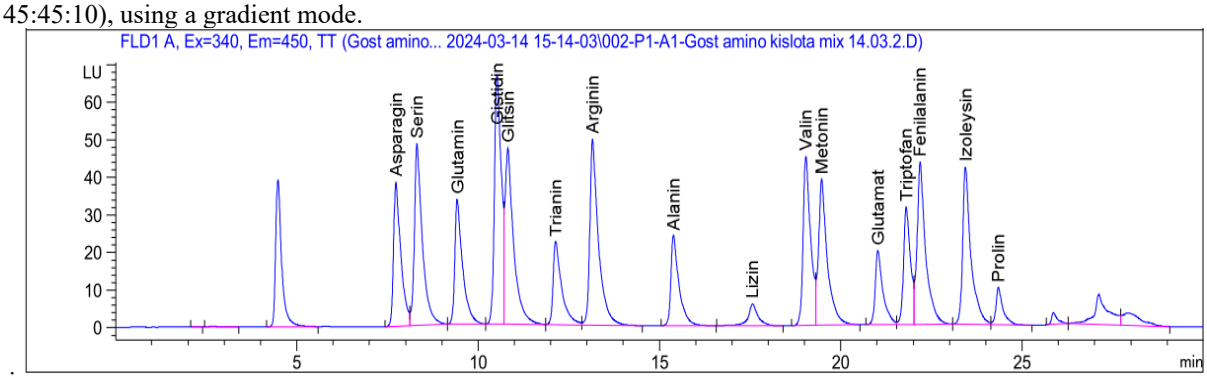

Figure 1. *Chromatogram obtained from standard samples of 16 different amino acids*

Hydrolysis of the amino acids contained in the sample was carried out as follows:First, all samples were ground to a size of 1 mm. A 5.0 g sample was ground and weighed to the nearest 0.001 mg using an analytical balance (FA220 4N). Next, the sample was placed in a 200 ml flask with a reflux condenser, 50 ml of hydrochloric acid (6 N) was added, and the flask was placed in a thermostat at 110°C. Hydrolysis was carried out for 24 hours with magnetic stirring. After hydrolysis was complete, the solution was cooled to room temperature, 10 ml was removed, and centrifuged for 10 minutes at 12,000 rpm. Then, 5 ml of the centrifugate was removed and neutralized with 6 N sodium hydroxide.After this, 1 ml of the solution was filtered through a filter with a pore size of 0.45 µm, placed in a vial and the following results were obtained [4,5,6,7].

Results and Discussion: The results obtained are presented in Table 1.

Table 1

Composition and quantity of amino acids of the root parts of the plant Ferula lipskyi, growing in the Fergana Valley

№	Name of indicators	Ferula lipskyi root parts (mg/g)	№	Name of indicators	Ferula lipskyi root parts (mg/g)
1.	Asparagin	0.00	9.	Lizin	0.53
2.	Serin	0.15	10.	Valin	0.08
3.	Glutamin	0.00	11.	Metonin	0.07
4.	Gistidin	0.00	12.	Glutamat	0.00
5.	Glitsin	0.79	13.	Triptofan	0.00
6.	Trianin	0.98	14.	Fenilalanin	0.01
7.	Arginin	0.20	15.	Izoleysin	0.17
8.	Alanin	0.02	16.	Prolin	0.21

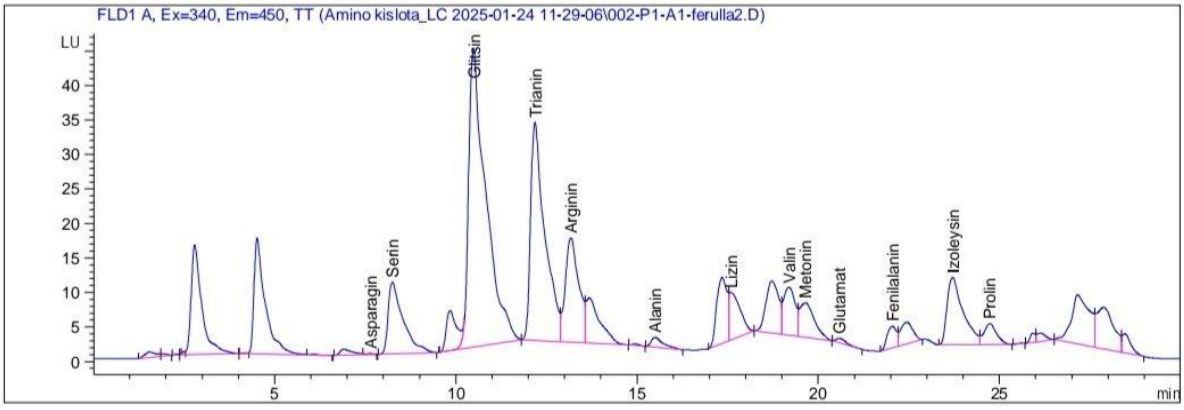

Figure 2. Chromatograms of amino acids obtained from samples of the root part of the plant Ferula lipskyi

Conclusion: Thus, the study of the amino acid composition of the roots of Ferula lipskyi, a plant grown in the Fergana Valley, revealed the presence of a number of physiologically important amino acids. High-performance liquid chromatography (HPLC) identified and quantified serine, glycine, threonine, arginine, alanine, lysine, valine, methionine, phenylalanine, isoleucine, and proline in the sample. However, asparagine, glutamine, histidine, glutamate, and tryptophan were not detected in the sample. Among the identified amino acids, the highest concentrations were found for threonine (0.98 mg/g), glycine (0.79 mg/g), and lysine (0.53 mg/g). The relatively high content of these amino acids indicates the biochemical value of Ferula lipskyi roots. Threonine is an essential amino acid and plays a key role in protein metabolism, immune system function, and maintaining metabolic processes in the body. Glycine is involved in the synthesis of biologically active compounds, and lysine is an important component of protein metabolism and tissue growth. A comparative analysis with representatives of the genus Ferula shows that the amino acid profile of Ferula lipskyi has its own distinctive features. Like other species of this genus, the plant contains a complex of biologically active substances, but the quantitative distribution of amino acids depends on the species, environmental conditions, soil composition, climatic factors, vegetation phase, and the plant part used. The predominance of threonine, glycine, and lysine in the roots of Ferula lipskyi distinguishes this species from several other representatives of the genus Ferula, for which variable accumulation of amino acids and other nitrogen-containing compounds is more often noted in the literature. The obtained results confirm that Ferula lipskyi is a promising plant material for further phytochemical and pharmacological study. The presence of essential and nonessential amino acids in the root parts of the plant allows this species to be considered a potential source of natural biologically active compounds that can be used in the pharmaceutical, food, and biotechnology industries.[8] However, the absence of asparagine, glutamine, histidine, glutamate, and tryptophan in the studied sample indicates the specificity of the amino acid composition of Ferula lipskyi and the need for further research using samples collected at different stages of the growing season and from different growing regions. This will allow for a more complete assessment of the chemical composition of the plant, the establishment of patterns of amino acid accumulation, and the determination of its practical significance among other species of the genus Ferula.

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EARTH SCIENCES

GEOPHYSICAL COMPLEXES IN MONITORING THE TECHNICAL CONDITION OF OIL WELLS

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Abstract

Safe and efficient operation of oil wells requires continuous monitoring of their technical condition. One of the main tools for such monitoring is well logging (well geophysics). Geophysical complexes represent a set of instruments and methods that make it possible to timely detect mechanical, hydrodynamic, and geological changes occurring during well operation. The main purpose of geophysical complexes is to assess the condition of well structural elements, prevent leaks and accidents, and optimize the production process. These complexes provide accurate information about the downhole environment, reservoir–well interaction, and the nature of fluid movement. The most widely used geophysical methods for monitoring the technical condition include logging, thermometry, profilemetry, inclinometry, and deviation measurements. Geophysical complexes play an important role in monitoring the technical condition of oil wells and are considered one of the key tools for ensuring safety, reliability, and economic efficiency in the modern oil and gas industry.

Keywords: oil wells technical condition monitoring, geophysical logging complexes, thermometry, inclinometry.

The efficient development of reservoirs and the sustainable maintenance of production in the modern oil and gas industry directly depend on the technical condition of oil wells. Oil wells are the primary technological structures that ensure the transfer of reservoir energy to the surface, and during operation, they function under complex geological and technical conditions. High reservoir pressures, temperature variations, aggressive chemical environments, mechanical loads, and long-term operation can lead to various types of deformations in the well structure, corrosion processes, leaks, and loss of structural integrity. Such problems not only result in reduced production but can also cause serious technological accidents, environmental pollution, and significant economic losses.

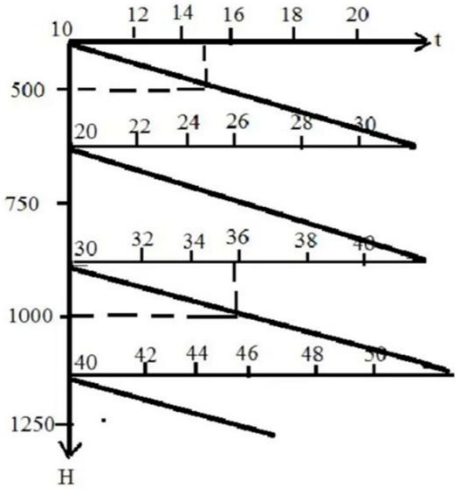
For this reason, the organization of continuous and systematic monitoring of the technical condition of oil wells is considered one of the main priorities of the oil and gas industry. Since traditional monitoring methods often fail to provide complete and accurate information about downhole processes, modern approaches increasingly rely on non-destructive and highly informative methods, among which well logging plays a particularly important role. Borehole geophysics is a scientific and technical field based on the study of physical fields and their interaction with the surrounding medium, enabling the assessment of the actual condition of the downhole environment and well structure [2].

Geophysical complexes are one of the most important application forms of borehole geophysics and involve the integrated use of various measurement methods, instruments, and software within a unified system. Through these complexes, the condition of casing strings, the quality of the cement sheath, the distribution of liquid and gas flows, the nature of the reservoir–well connection, as well as changes in the geometric parameters of the well can be determined with high accuracy. The advantage of geophysical complexes lies in their ability to carry out diagnostic operations without stopping well production or with only minimal interruption.

Geophysical complexes used for monitoring the technical condition of oil wells are based on multifaceted and complex approaches. By combining methods grounded in different physical principles, these complexes ensure accurate assessment of both the well structure and the properties of the surrounding formations. Electrical logging methods, based on the electrical conductivity and dielectric properties of rocks, make it possible to determine fluid saturation within the well, identify formation boundaries, and detect potential leakage zones. Acoustic logging methods analyze the propagation velocity of sound waves in the rock medium, helping to assess the mechanical stability of the well and detect fractures and voids. Radioactive logging methods provide information about the density, composition, and degree of mineralization of rocks, which significantly

contributes to the analysis of geological characteristics of formations as well as to production planning [1].

The thermometry method, as another key component of the geophysical complex, ensures accurate measurement of temperature distribution within the well. Through this method, the presence of abnormal flows, leakage zones, and interlayer communication can be identified. In the interpretation of the thermogram curve, it is also possible to calculate the geothermal gradient and the geothermal step. Specifically, the temperature corresponding to depth at selected intervals is determined from the thermogram, and based on known formulas; the geothermal step and geothermal gradient are calculated. Data obtained from the temperature profile make it possible to determine the direction of fluid movement along the wellbore, assess the quality of cementing, and detect potential problems in annular spaces. Thus, the thermometry method not only serves to obtain geothermal data but also supports the early detection of engineering issues in the well and the timely implementation of technical decisions.



Pic.1 Thermogram obtained by thermometry

Profilemetry, deviation measurement, and inclinometry methods are widely used to study the geometric condition of the well, including diameter variations, curvature, and the level of mechanical deformation. The profilemetry method allows precise determination of the internal profile of the well, providing essential information for casing placement, optimization of the cementing process, and installation of pipe systems. Deviation and inclinometry methods monitor the inclination, bending, and deformation processes of the well axis, thereby enabling the assessment of geological and technical risks. The integrated application of all these methods results in the formation of a comprehensive and objective database on the technical condition of the well [6].

In modern times, geophysical complexes have been further improved through digital technologies, automated measurement systems, and real-time data processing capabilities. This not only facilitates data acquisition but also enables its prompt analysis, early identification of risks, and the adoption of optimal technical decisions. As a result, the process of monitoring the technical condition of wells becomes more efficient and reliable. Potential accidents during drilling and operation are prevented, the effectiveness of repair and maintenance activities is increased, production processes are optimized, and the operational lifespan of oil fields is extended. This approach clearly demonstrates the importance of integrating geophysical methods and applying modern technologies for the safe and sustainable operation of wells.

In monitoring the technical condition of oil wells, geophysical complexes serve not only as diagnostic tools but also as strategically important scientific and technical instruments that ensure the safe, reliable, and economically efficient exploitation of oil and gas fields. In this regard, studying the capabilities of geophysical complexes and expanding their areas of application remain among the key priorities of modern oil and gas science and industry [4].

Effective monitoring of the technical condition of oil wells is of great importance in the oil and gas industry in terms of ensuring production sustainability, maintaining industrial safety, and increasing economic efficiency. During well operation, mechanical wear, corrosion, deformation of tubing and casing strings, damage to the cement sheath, interlayer flows, and leaks of various origins can lead to serious technical and environmental problems. The timely detection of these issues is almost impossible without the application of modern geophysical complexes.

Research results have shown that geophysical complexes make it possible to obtain comprehensive and reliable information about processes occurring within the well, ensure operative assessment of the technical condition, and demonstrate high effectiveness in the early detection of hidden defects. The integrated application of electrical, acoustic, radioactive, and other geophysical methods enables an objective evaluation of the integrity of well structures, the quality of cementing, and interlayer communication. The use of geophysical complexes in monitoring the technical condition of oil wells is a necessary and promising direction in the modern oil and gas industry, and the development of scientific research and new technological solutions in this field is of particular importance.

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EVALUATION OF RESERVOIR SATURATION USING METHODS OF MINING GEOPHYSICS

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Abstract

The article is devoted to the evaluation of reservoir rock saturation using well logging methods in petroleum geophysics. The main objective of the study is to determine porosity, shale content, and fluid saturation of formations based on well logging data. The paper analyzes the interpretation principles of gamma ray logging, neutron logging, electrical and induction logging, as well as other integrated geophysical methods. As an exampl petrophysical parameters were calculated to determine the oil, gas, and water saturation of the formations, and the obtained results were comparatively evaluated. Also the capabilities and limitations of geophysical methods under various geological conditions were discussed. Reflected that using of modern geophysical technologies, high-precision logging systems, and digital interpretation software not only ensures the scientific validity of saturation assessment but also contributes to more accurate reserve estimation, the timely identification of non-productive and low-productive zones. Obtaining results of the study contribute to refining reservoir quality assessment and support effective decision-making in field development.

Keywords: petroleum geophysics, well logging, reservoir, saturation, saturation, porosity, shale content.

Mining geophysics is one of the key scientific and applied disciplines in the modern oil and gas industry, aimed at studying the petrophysical properties of reservoir rocks and evaluating the degree of saturation of formations with oil, gas, and water [1-4]. The efficient development of hydrocarbon deposits, accurate estimation of reserves, and optimization of development projects directly depend on the precise determination of reservoir quality indicators, particularly porosity, permeability, and saturation parameters [5, 6].

In this context, geophysical investigations carried out in boreholes; especially well logging methods, serve as one of the most important sources of continuous and real-time information about the physical properties of formations [7-9]. The concept of saturation in reservoir rocks characterizes the relative proportion of fluids—oil, gas, and water—contained within the pore volume. Although total saturation represents the sum of all fluids in the pore space, from an industrial perspective the most significant indicators are the oil and gas saturation coefficients.

The water saturation coefficient, in turn, is considered a key parameter both for evaluating reservoir efficiency and for estimating reserves [2]. The saturation characteristics of a formation vary depending on the lithological composition of the rock, pore structure, degree of cementation, content of clay minerals, as well as capillary pressure and electrical properties. Therefore, the evaluation of saturation requires a comprehensive approach and the integration of several geophysical methods.

The most widely used methods for determining saturation in mining geophysics are electrical and induction logging, neutron logging, and gamma logging [4, 5]. Electrical and induction methods measure the specific electrical resistivity of a formation, providing information about the conductivity of the fluid contained in the pore spaces. It is well known that when the mineralization of formation water is high, its electrical conductivity increases; consequently, as water saturation increases, the overall resistivity of the rock decreases.

Neutron logging is primarily sensitive to the hydrogen content of the rock and plays an important role in determining porosity. Since the amount of hydrogen atoms is closely related to the volume of fluid in the pores, the neutron method provides information about both porosity and, indirectly, saturation. In gas-bearing formations, a decrease in neutron log readings is known as the "gas effect," and this feature is considered an important diagnostic indicator for identifying gas reservoirs.

Gamma logging measures the natural radioactivity of rocks and makes it possible to evaluate clay content. Accurate determination of clay content is essential for calculating saturation, as the clay fraction reduces effective pore volume and influences electrical measurements.

During petrophysical modeling, laboratory analyses, geophysical well logging data, and hydrodynamic parameters are considered together. Total and effective porosity are distinguished, cementation and tortuosity factors are taken into account, and capillary pressure curves are utilized. Digital interpretation software enables the correlation of various logging curves. This allowing a more accurate determination of the lithological model of the formation and the distribution of fluids.

The complexity of the geological environment is one of the key factors that directly and multifaceted influences the accurate evaluation of reservoir saturation. In particular, in carbonate reservoir rocks, widely developed fracture systems and dual porosity

lead to an uneven distribution of fluids within the formation. This creates additional uncertainties in the interpretation of geophysical parameters such as electrical resistivity, density, and neutron porosity. In terrigenous rocks, heterogeneity, variability in grain composition, differences in the degree of cementation, and abrupt changes in stratification can reduce the accuracy of empirical relationships used in determining saturation. As a result, the same geophysical parameter may have different physical meanings under different geological conditions, making the interpretation process more complex and multi-variant.

Therefore, it is essential that geophysical data be consistently integrated with the geological model, meaning that lithological, petrophysical, and structural characteristics must be analyzed in a comprehensive manner. Structural and tectonic features—such as faults, flexures, block structures, and zones of tectonic stress—have a significant impact on both the distribution and filtration properties of reservoirs. At the same time, facies variations and sedimentation conditions lead to spatial changes in the porosity and permeability of rocks. For example, reservoir properties of rocks formed in coastal-marine environments can differ significantly from those deposited in deep-marine settings. All these factors collectively have a direct influence on reservoir quality, saturation characteristics, and production potential.

One of the most important tasks facing modern mining geophysics during drilling is the accurate identification of oil and gas-bearing formations and the evaluation of their productivity. Determining the saturation characteristics of reservoirs (oil, gas, or water) is not achieved through a single method, but rather through the integrated analysis of mud logging (gas logging) and geophysical well logging data. This approach allows for a more comprehensive understanding of the geological section and helps minimize uncertainties that may arise during drilling.

Gas logging is based on studying the quantity and composition of hydrocarbon gases present in the drilling fluid circulating during the drilling process [5]. The main advantage of this method is its ability to provide data in real time. As the rock is broken, the fluids it contains enter the drilling mud and are recorded at the surface using gas analyzers. The ratio of methane and its homologs (ethane, propane, butane) helps provide a preliminary assessment of whether the formation is oil-bearing or gas-bearing. A sharp increase in gas readings is a direct indication of entering a reservoir zone. However, since the parameters of the drilling fluid and technological factors can influence these readings, they must be taking into account. One of the most important tasks facing modern mining geophysics during drilling is the accurate identification of oil and gas-bearing formations and the evaluation of their productivity. Determining the saturation characteristics of reservoirs (oil, gas, or water) cannot be achieved using a single method; rather, it requires the integrated analysis of mud logging (gas logging) and geophysical well logging data. This approach makes it possible to obtain more comprehensive information about the geological section and to minimize uncertainties that may arise during drilling.

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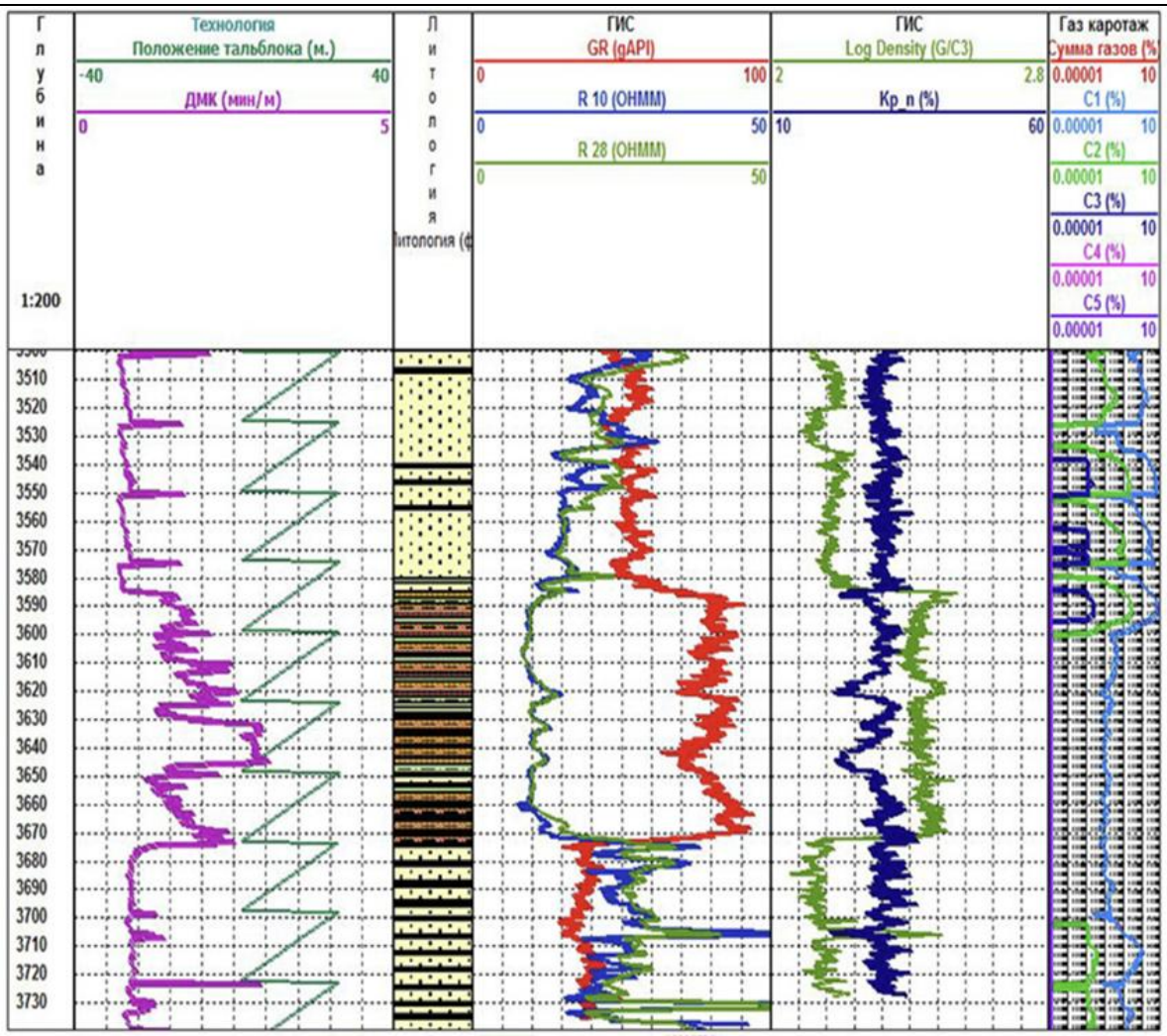

Pic. 1. Diagram of complex assessment of reservoir saturation based on gas logging and geophysical logging

The figure presents the results of comprehensive geophysical well logging studies in the form of a multi-track diagram, allowing the evaluation of the lithological structure of formations, their physical properties, and fluid saturation. On the left side, the depth scale of the well (approximately 3500–3730 m interval) is shown. Next to it, technological parameters—particularly the rate of penetration (DMK) during drilling and the condition of the drilling tool—are provided. These data give a preliminary understanding of rock strength and drilling conditions. The next track displays the lithological section, where different symbols are used to distinguish sandy, clayey, and layered rocks. This column helps in the initial differentiation between reservoir and non-reservoir intervals. In the middle section, geophysical logging curves are presented: Gamma-ray logging (GR) indicates the natural radioactivity of the rock and is mainly used to evaluate clay content (higher GR corresponds to higher clay content). Electrical resistivity logs (R10, R28) reflect the electrical properties of the formation; high resistivity is typically associated with oil or gas saturation, while low resistivity indicates water saturation. On the right side, density logging and porosity (Kp) curves are shown. These parameters make it possible to assess pore volume and reservoir quality. The rightmost track represents gas logging results, showing the total gas content as well as variations in individual components (C1 – methane, C2 – ethane, C3–C5, etc.). An increase in gas components indicates entry into reservoir zones and the presence of hydrocarbons. Overall, the figure is used to identify reservoir intervals and evaluate their porosity and saturation characteristics (oil, gas, or water) based on the integrated interpretation of geophysical and gas logging data.

Overall, the evaluation of reservoir saturation using mining geophysical methods is a complex, multi-stage process that requires a scientifically grounded and integrated approach. This process includes the collection of initial data, quality control, comparative analysis of different geophysical methods, construction of petrophysical models, and final interpretation. The use of modern technologies such as high-precision logging tools, digital interpretation software, and 3D geological modeling systems significantly improves the reliability of the results. In addition, the application of integrated interpretation methods enables more accurate reserve estimation, timely identification of non-productive or low-productive intervals for exclusion from production, and optimization of reservoir development strategies.

The integrated application of various geophysical methods, as well as the correlation of the obtained results with geological and petrophysical data, enables a more accurate, objective, and reliable determination

of saturation in water, oil, and gas reservoirs. This approach is not limited to the results of individual methods; it also involves a multiparameter interpretation that takes into account lithological, structural, tectonic, and stratigraphic characteristics. This helps to overcome the difficulties caused by geological complexity, such as fracturing and dual porosity in carbonate rocks, as well as heterogeneity and layered variability in terrigenous formations.

Using of modern geophysical technologies, high-precision logging systems, and digital interpretation software not only ensures the scientific validity of saturation assessment but also contributes to more accurate reserve estimation, the timely identification of non-productive and low-productive zones. Additionally it lead to the efficient and rational development of hydrocarbon fields, thereby significantly reducing economic and operational risks in the oil and gas industry.

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ECONOMIC SCIENCES

A BLOCKCHAIN-BASED FRAMEWORK FOR VERIFIABLE MILITARY LOGISTICS WITH ZERO-KNOWLEDGE PRIVACY

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Abstract

Modern military logistics and command systems face significant challenges in terms of security, transparency, and verifiability. Traditional centralized systems are vulnerable to single points of failure and malicious attacks, while the transmission of sensitive orders and supply manifests risks interception. This paper proposes a novel framework that leverages a permissioned blockchain to create an immutable and auditable ledger for both physical asset and information logistics. To address the critical need for confidentiality, our framework integrates Zero-Knowledge Proofs (ZKPs), enabling military units to verifiably confirm not just the receipt, but the correct content and understanding of commands or assets without revealing any operational data on-chain. This approach ensures end-to-end integrity, non-repudiation, and resistance to future quantum decryption threats while maintaining the highest level of data privacy. We present the system architecture, detail the interaction protocols, and demonstrate its effectiveness through practical use case scenarios, including the secure delivery of sensitive assets and commands.

Keywords: blockchain, military logistics, zero-knowledge proofs, cybersecurity, data privacy, zk-SNARKs

This The efficiency and security of military logistics are paramount to operational success. Traditional command and supply chain systems, often centralized, present significant vulnerabilities, including susceptibility to targeted cyber-attacks, data manipulation, and human error. The flow of both physical assets, such as weaponry and supplies, and informational assets, such as commands and intelligence, must be protected not only from external adversaries but also from insider threats. A compromised logistics network can lead to mission failure, loss of assets, and endangerment of personnel.

In recent years, blockchain technology has emerged as a promising solution for enhancing the transparency and integrity of supply chains in the commercial sector. Its decentralized nature offers resilience against single points of failure, while its cryptographic linking of blocks creates an immutable audit trail. However, the inherent transparency of traditional blockchains is fundamentally incompatible with the stringent confidentiality requirements of military operations. Publicly viewable transaction details, even on a permissioned network accessible only to allies, can leak critical metadata about troop movements, supply levels, and operational tempo.

This paper addresses this critical gap by proposing a novel framework that combines the immutability of a permissioned blockchain with the powerful privacy-preserving features of Zero-Knowledge Proofs (ZKPs). ZKPs allow for the verification of actions—such as receiving a secret order or confirming the contents of a sensitive cargo—without revealing any underlying data. Our contribution is a holistic architecture that treats both physical and informational assets as part of a unified, verifiable logistics system. This ensures that commands are not only received but correctly understood, and assets are not only delivered but their integrity is confirmed, all while preserving complete operational secrecy.

The remainder of this paper is structured as follows. Section II reviews related work in blockchain for logistics and military applications. Section III details the proposed system architecture. Section IV presents practical use case scenarios. Section V provides a security analysis of the framework, and Section VI concludes the paper.

The application of blockchain technology to enhance supply chain management has been a subject of extensive research, demonstrating its capability to provide transparency, traceability, and immutability. Studies have shown its effectiveness across diverse sectors, from large-scale retail logistics [1] to securing pharmaceutical [2] and electronics [3] supply chains against counterfeiting. These systems leverage the blockchain's shared ledger to create a single, tamper-proof source of truth. However, the operational environments of military logistics impose strict confidentiality requirements that are fundamentally incompatible with the inherent transparency of traditional blockchain architectures.

Consequently, research in sensitive domains has converged on permissioned blockchains, where participation is restricted to known, vetted entities. While this limits public visibility, it introduces the critical challenge of internal data leakage among mutually mistrusting participants on the same network.

Several architectural patterns have been proposed to address this. One strategy is architectural segregation: Ding et al. propose a double-layer framework where sensitive data remains on private enterprise blockchains, sharing only traceability tags on a main consortium chain. Similarly, Malik et al. utilize a sharded architecture governed by Access Control Lists (ACLs) to physically separate competitors' data [5,6].

Another set of solutions leverages off-chain storage or native platform privacy features. Ferdousi et al. propose keeping sensitive data (e.g., cattle health records) in local databases, recording only cryptographic hashes on-chain to maintain confidentiality while enabling integrity checks [7]. More advanced approaches, such as those by Ravi et al. using Hyperledger Fabric, employ "channels" for private sub-networks and leverage Identity Mixer (based on Zero-Knowledge Proofs) to provide user anonymity and unlinkability [8].

While effective to a degree, these existing solutions leave a critical gap for military logistics. Architectural segregation creates silos, hindering a unified audit trail. Off-chain hashes prove data integrity but cannot cryptographically verify complex conditions—such as whether a secret command was correctly interpreted or if a secure container's contents match the manifest—without revealing the data to the verifier. Furthermore, existing ZKP implementations like Identity Mixer focus on protecting the who (identity), whereas military operations often require protecting the what (operational data) while still proving it happened correctly.

This paper addresses this gap by proposing a framework where the blockchain functions primarily as a management and control layer, not a data storage layer. We introduce general-purpose zk-SNARKs to enable verifiable "information logistics." Unlike previous approaches, our system allows a unit to cryptographically prove not just the receipt of an asset, but the correctness of its content and the accurate interpretation of associated secret commands, all without ever exposing sensitive operational data on the shared ledger. This ensures a unified, auditable chain of command and custody while maintaining absolute operational security [9].

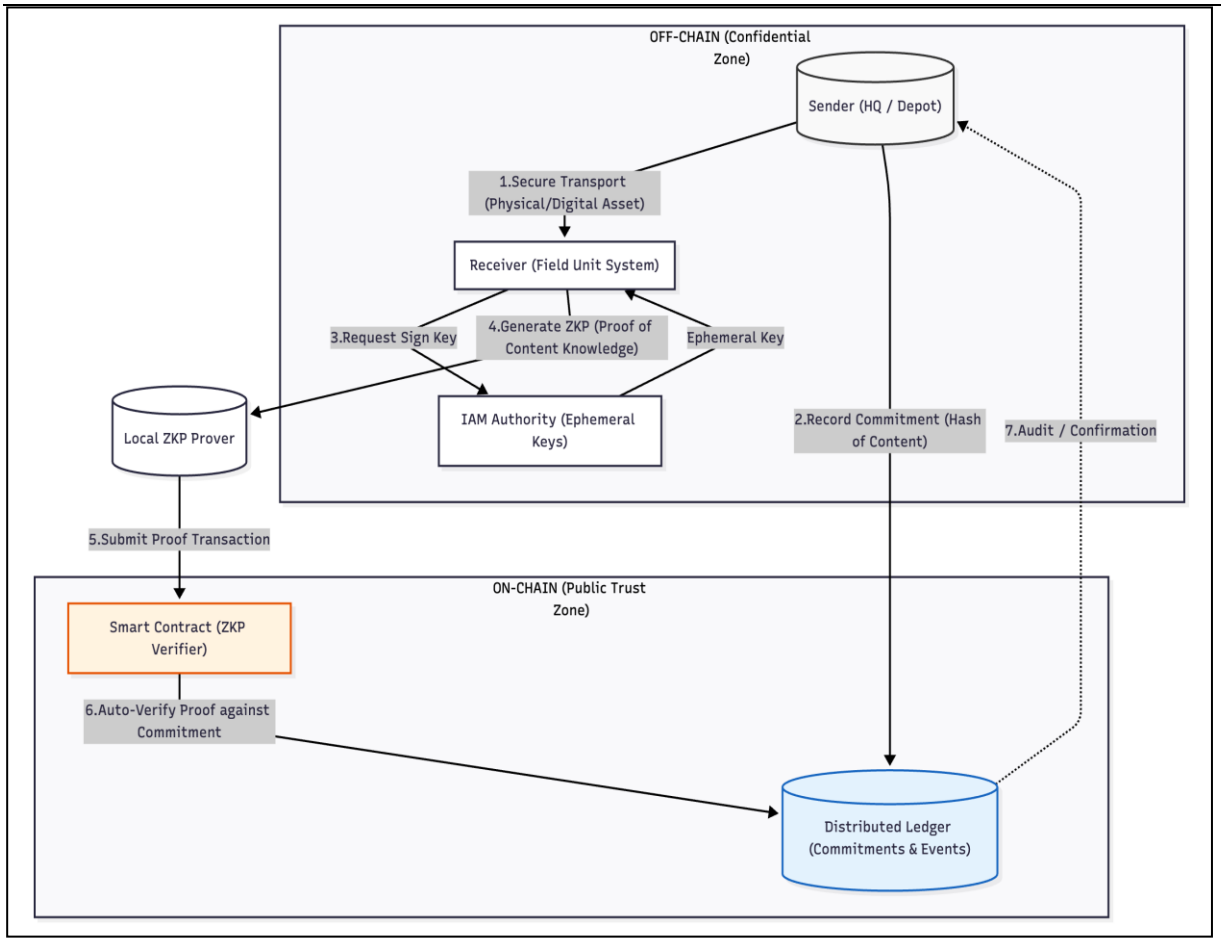
We propose a unified framework designed to secure and control disparate logistical flows—both physical (e.g., sensitive cargo) and informational (e.g., secret orders)—under a single verifiable regime. Our approach leverages the blockchain specifically as a secure management and control layer for cryptographic proofs, rather than a repository for operational data. This simultaneously achieves two critical objectives: ensuring strict confidentiality of sensitive data off-chain, and providing enhanced on-chain verifiable control. Unlike traditional systems that only confirm receipt, our framework enables the headquarters to cryptographically verify that a unit has received the correct cargo content or has correctly interpreted a secret order, without ever exposing that content to the network.

A. The Essence of Zero-Knowledge Proofs

The theoretical foundation of this enhanced control rests on Zero-Knowledge Proofs (ZKPs). Introduced by Goldwasser, Micali, and Rackoff, ZKPs are protocols that allow a 'prover' to convince a 'verifier' that a statement is true without revealing any information beyond the validity of the statement itself [10]. Modern non-interactive implementations (like zk-SNARKs) are suitable for blockchain environments and can handle complex verification logic. It has been proven that any problem in NP—which includes verifying cargo manifests or validating answers to challenge questions rooted in secret orders—has a zero-knowledge proof system [11]. This theoretical foundation ensures that our framework can support highly complex logistical verification conditions while maintaining minimal computational overhead for on-chain validation. In our system, ZKPs are used to prove knowledge of correct content—for example, that a unit possesses a specific anti-tamper token found inside a sealed container, or knows the correct answers to challenge questions embedded within a secret order—without ever revealing that token or those answers to the blockchain network.

B. Architectural Components

The system architecture employs a strict separation of data and proofs to mitigate future quantum decryption threats ("harvest now, decrypt later") and traffic analysis (Fig. 1).



Generic Framework Architecture & Workflow for Verifiable Logistics.

The framework consists of four primary components (see Fig. 1):

- Off-Chain Secure Environment: The "secret" layer where actual operational data resides. This includes HQ servers (issuing orders/manifests) and Unit local systems (receiving and processing them).
- Permissioned Blockchain Network: The "trust" layer acting as the single source of truth for the state of operations. It stores only opaque cryptographic commitments (hashes) and ZKP proofs.
- Identity and Access Management (IAM): An off-chain authority that manages long-term identities and issues ephemeral, one-time keys for signing specific on-chain transactions, ensuring unlinkability of actions.
- ZKP Core Modules:
  - Prover (Client-side): Generates proofs based on private off-chain inputs (e.g., scanned internal cargo codes, answers to order verification questions).
  - Verifier (On-chain): A smart contract that automatically validates submitted proofs against on-chain commitments.

C. Generic System Workflow

Fig. 1 illustrates the generalized workflow. The key innovation is in Step 4, where the proof is generated not just for receipt, but for knowledge of content.

- Asset Initiation (Off-Chain): The Sender (HQ) prepares the asset.
  - For Cargo: Sealed container with a secret internal token.
  - For Info: Secret order with embedded "challenge questions" to verify understanding.
- Commitment (On-Chain): HQ records a cryptographic commitment (hash of the token or correct answers) on the Ledger.
- Secure Transport (Off-Chain): The asset is delivered via standard secure channels.
- Internal Validation & Proof Generation (Off-Chain): The Receiver accesses the content (scans the token OR answers the challenge questions). These private inputs are fed to the local ZKP Prover to generate a proof_of_valid_content.

Transaction & Verification (On-Chain): The Receiver submits the proof to the Smart Contract using an ephemeral key. The contract verifies the proof against the initial commitment. A successful verification immutably updates the operation's state, providing HQ with absolute assurance of correct delivery and interpretation without data leakage.

To demonstrate the practical applicability and versatility of the proposed framework, we present two distinct operational scenarios: the secure delivery of sensitive physical assets and the verifiable dissemination of confidential orders. Both scenarios leverage the same underlying architectural components but utilize different private inputs for ZKP generation.

D. Scenario 1: Verifiable Cargo Delivery (Physical Logistics)

Operational Problem: A Headquarters (HQ) dispatches a sealed container with critical electronic warfare (EW) modules to a forward Unit. Traditional

logistics can only confirm the handover of the container to the courier. It cannot guarantee that the contents haven't been tampered with en route without forcing the courier to open it (breaking confidentiality) or waiting for a delayed off-band confirmation from the Unit (breaking real-time tracking).

Proposed Solution Workflow:

- Initialization: HQ places a unique, passive cryptographic tag (e.g., NFC) inside the secure container along with the EW modules. The tag contains a high-entropy secret, HQ records the commitment on the blockchain.
- Transport: The courier transports the sealed container. They confirm custody transfers on-chain, but these only track the container, not its verified contents.
- Verification: Upon receipt, the Unit moves the container into a secure perimeter and opens it. They scan the internal tag to retrieve.
- Proof: The Unit's system generates a ZKP proof asserting knowledge of the secret that matches the on-chain commitment.
- Outcome: The smart contract verifies proof and updates the shipment status to "Content Verified." HQ receives immediate, irrefutable confirmation that the actual assets reached the destination intact, while the specific nature of those assets (represented by secret) remains unknown to the courier and the blockchain network.

E. Scenario 2: Proof of Understanding (Information Logistics)

Operational Problem: HQ transmits a complex, highly classified Operation Order (OPORD) to dispersed subordinate commanders. Standard encrypted channels (like email or specialized messengers) provide delivery receipts but cannot cryptographically verify that the recipient has successfully decrypted the file, read it, and understood the critical synchronization points (e.g., H-Hour, abort codes)..

Proposed Solution Workflow:

- Initialization: HQ embeds a set of "challenge questions" within the encrypted OPORD. These questions relate to mission-critical parameters (e.g., "What is the secondary rally point coordinates?"). HQ hashes the expected correct answers and commits this hash to the blockchain.
- Transmission: The encrypted OPORD is sent via secure off-chain channels.
- Verification: The receiving commander decrypts the OPORD. To "unlock" the confirmation process, they must correctly answer the challenge questions locally.
- Proof: The local ZKP module takes the commander's answers as private input and generates a proof.
- Outcome: The on-chain verification of the proof serves as a "Proof of Understanding." It cryptographically assures HQ that the unit is not only in possession of the order but is also operationally synchronized, without ever exposing mission details (rally points, times) on the ledger. This capability is critical for preventing failures due to misinterpretation of orders in high-stakes environments.

Military logistical networks operate under a threat model significantly more hostile than commercial supply chains. Adversaries possess advanced capabilities for traffic analysis, long-term data harvesting, and potential insider compromise. Our framework addresses these high-stakes threats through its hybrid architecture.

F. Mitigation of Long-Term Cryptographic Risks

A critical vulnerability in standard blockchain deployments is the permanent storage of encrypted data on-chain. This exposes operations to "harvest now, decrypt later" attacks, where adversaries store current encrypted traffic to decrypt it once quantum computing becomes viable. Our framework neutralizes this threat through strict data minimization. Sensitive operational details (cargo manifests, order contents) never leave the secure off-chain environment. The on-chain ledger contains only cryptographic commitments (hashes) and ZK-proofs. Even if an adversary breaks the underlying encryption algorithms in the future, the on-chain data remains semantically opaque, as it is computationally impossible to reverse-engineer the original high-entropy operational data from its hash or ZKP.

G. Operational Security via Unlinkability

Traditional blockchains, even permissioned ones, often leak metadata through transaction patterns, allowing adversaries to infer command hierarchies or operational tempos (e.g., observing a spike in transactions from a specific HQ node to a specific forward unit). We mitigate this by decoupling long-term identities from on-chain actions. By utilizing standard Identity and Access Management (IAM) to issue ephemeral, one-time keys for each transaction, an outside observer sees only a stream of unrelated interactions between temporary addresses. The ZKP further ensures that the content of these interactions cannot be correlated, preserving operational security (OpSec).

H. Unlinkability Integrity and Non-Repudiation

In a chaotic operational environment, the risk of internal error or sabotage (e.g., false reporting of receipt) is high. The ZKP-based verification provides a stronger integrity guarantee than simple digital signatures. A signature only proves who sent a message, whereas our ZKP proves what was verified true by the sender.

- Soundness: The mathematical properties of zk-SNARKs guarantee that it is computationally infeasible for a compromised unit to generate a valid proof of receipt if they do not actually possess the correct secret token or answers.
- Non-Repudiation: Once a valid proof is committed on-chain, the receiving unit cannot later deny having received or understood the order, creating an immutable audit trail for command accountability.

Modern military logistics demands a difficult balance: operations must be auditable and coordinated across diverse units, yet strictly confidential to withstand adversarial surveillance. Traditional systems force a trade-off between these requirements. This paper presented a novel framework that resolves this conflict by fundamentally redefining the role of blockchain in military applications.

Instead of using the ledger as a secure data repository—a practice we identify as vulnerable to long-term cryptographic threats—our framework utilizes it exclusively as a management and verification layer. By integrating Zero-Knowledge Proofs, we have elevated the standard of logistical control from simple "Proof of Receipt" to "Proof of Content Knowledge" and "Proof of Understanding." This capability is particularly transformative for "information logistics," allowing commanders to cryptographically verify that a subordinate has not only received a secret order but has correctly interpreted its critical parameters, without ever exposing those parameters to the network.

Our security analysis confirms that this hybrid on-chain/off-chain architecture effectively neutralizes key threats, including traffic analysis and "harvest now, decrypt later" quantum attacks, by ensuring that sensitive data never leaves secure off-chain environments.

A promising avenue for future research lies in extending this framework to verify mission execution outcomes without revealing operational details. This could be achieved by integrating Zero-Knowledge Machine Learning. For instance, a field unit could use a local neural network to analyze drone imagery and generate a cryptographic proof that a specific target has been neutralized according to predefined criteria, without ever transmitting the sensitive raw footag**e to headquarters.**

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JURISPRUDENCE

DOCTRINAL GAPS IN THE CRIMINALIZATION OF UNLAWFUL DEPRIVATION OF LIBERTY, FORCED MARRIAGE, AND ENGAGEMENT PRACTICES OF MINORS IN GEORGIA

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Abstract

This study examines the doctrinal gaps in the criminalization of marriage-related coercive practices within the framework of Georgian criminal law. A key issue lies in the fact that the offence of unlawful deprivation of liberty does not fully encompass cases of abduction for the purpose of marriage, while the offence of forced marriage fails to cover informal practices such as the engagement of minors. The aim of the research is to identify these normative gaps and to provide a systematic legal assessment. The study employs doctrinal and comparative legal methods. The findings demonstrate that the existing regulatory framework is fragmented and generates legal gaps, within which certain forms of marriage-related coercion remain outside the scope of effective criminal law protection.

Keywords: Unlawful deprivation of liberty; Forced marriage; Protection of minors; Abduction for the purpose of marriage; Engagement practices of minors; Criminalization; Doctrinal analysis

Introduction

Marriage-related coercive practices constitute a complex socio-legal phenomenon (Council of Europe, 2011; UNODC, 2022) that transcends the boundaries of a single legal system and is characterized by transnational and transcultural prevalence. Such practices manifest in various forms across both developed and developing legal systems; however, the scope and intensity of their criminalization vary significantly depending on cultural, historical, and normative factors.

Within the post-Soviet legal space, including Georgia, the criminal law model has historically been based on a formalized and relatively narrow approach to offences against personal liberty. This model often fails to capture the subtle socio-cultural forms of coercion related to marriage, which extend beyond the framework of classical criminal conduct and enter the realm of "normalized" social practices.

Particular attention should be paid to the historical transformation of abduction for the purpose of marriage. While in earlier legal regimes this act was recognized as a distinct or clearly identifiable criminal category, in contemporary criminal law it has partially "disappeared" or been dispersed across various offences. This has led to a reduction in its doctrinal visibility and to the fragmentation of its legal qualification (Georgia, 1999; UNODC, 2022). As a result, certain forms of marriage-related coercive conduct remain within a space of inconsistent interpretation, thereby exacerbating inequalities in protection standards and generating legal gaps.

The existing criminal law doctrine does not provide a unified and systematically structured regulatory framework for marriage-related coercive practices. This results in significant normative gaps and inconsistencies in legal assessment.

First, the offence of unlawful deprivation of liberty, despite its broad formulation, does not fully cover situations in which a person's liberty is restricted specifically for the purpose of marriage. Consequently, abduction for the purpose of marriage often fails to fall clearly and unequivocally within the doctrinal scope of this offence, thereby reducing the effectiveness of its criminalization.

Second, the offence of forced marriage, although intended to prevent the imposition of marriage against an individual's will, does not encompass informal social practices such as the engagement or betrothal of minors. These practices, particularly within certain ethnic and cultural contexts, function as de facto coercive mechanisms leading to marriage; however, they are often not legally recognized as forms of forced marriage.

Third, the regulatory framework for the protection of minors is characterized by fragmentation. Existing norms do not establish a unified, coherent, and sufficiently comprehensive legal framework capable of effectively identifying and preventing all forms of marriage-related coercion (UNODC, 2022; Freedom House, 2023).

As a result, the diffuse and incomplete regulation of these three dimensions creates a systemic research gap that requires a unified doctrinal understanding and a reassessment of the scope of criminalization.

Research Aim: The aim of this study is to identify the doctrinal gaps in the criminal law regulation of marriage-related coercive practices and to provide a systematic legal assessment within the framework of Georgian legislation.

The research pursues two main objectives. First, it seeks to identify the normative gaps arising from the interaction between unlawful deprivation of liberty, forced marriage, and engagement or informal marriage practices involving minors. Second, it aims to conduct a doctrinal analysis of these offences by examining their content, scope, and practical applicability.

Furthermore, the study attempts to provide a systemic understanding of the fragmented nature of the existing regulation and to identify legal approaches that

would enable a more coherent and unified criminalization of various forms of marriage-related coercion.

Research Objectives: In order to achieve the research aim, the study addresses the following key objectives:

First, it conducts a doctrinal analysis of the criminal law provisions regulating marriage-related coercive practices, including a substantive and systemic assessment of the offences of unlawful deprivation of liberty and forced marriage.

Second, it undertakes a comparative legal analysis, evaluating the approaches of different legal systems to marriage-related coercion, including abduction for the purpose of marriage and mechanisms for the protection of minors. This component aims to identify relevant international standards and best practices.

Third, it identifies practical gaps, specifically those situations in which the existing legal framework fails to provide an effective response to all forms of marriage-related coercion.

Object and Subject of the Study: The object of the research is the criminal law regulation of marriage-related coercive practices within the legal system of Georgia.

The subject of the research is the doctrinal gaps within this regulatory framework, as well as unregulated or insufficiently regulated practices related to marriage, including the social and legal forms of engagement or betrothal involving minors.

Unlawful Deprivation of Liberty and Abduction for the Purpose of Marriage

Unlawful deprivation of liberty constitutes one of the fundamental offences in criminal law, aimed at protecting an individual's freedom of movement and autonomy of will. According to Article 143 of the Criminal Code of Georgia, unlawful deprivation of liberty refers to the illegal restriction of a person's freedom, irrespective of the form in which it is carried out. The content of the provision typically encompasses the physical or other factual restriction of a person against their will, thereby ensuring the constitutional and international legal protection of individual liberty. The doctrinal construction of this offence is based on a general understanding of personal freedom, with primary emphasis placed on the fact of restriction itself rather than a detailed differentiation of its purposive motivation (Georgia, 1999; Giorgadze, 2022).

However, specific cases of abduction for the purpose of marriage raise significant doctrinal issues, insofar as such conduct historically represented a distinct manifestation of unlawful deprivation of liberty, directly linked to the implementation of forced marriage objectives (Georgia, 1960; Georgia, 1999). In contemporary criminal law regulation, this purposive element is often no longer explicitly identified, as a result of which abduction for marriage purposes may fall within the scope of a general formulation, while simultaneously losing its specific legal character.

This situation gives rise to doctrinal inconsistency, since the norm of unlawful deprivation of liberty does not distinguish the purposive element of the act—namely, the aim of coercing marriage—as a qualifying or aggravating circumstance. Consequently, cases of abduction for marriage purposes are legally interpreted within the framework of a general offence, which diminishes the visibility of the act's socio-legal significance and complicates the possibility of establishing a specialised preventive regulation.

Moreover, this doctrinal approach creates a discrepancy between historical and contemporary legal realities: whereas in earlier legal systems abduction for the purpose of marriage constituted a clearly identified category of criminal conduct, in modern regulation it has been partially "dissolved" within the general doctrine of deprivation of liberty. This shift represents one of the central issues analysed in the present study.

Historical Regression and the Omission of the Element of Marital Purpose

The historical development of the regulation of abduction for the purpose of marriage clearly demonstrates a significant shift in criminal policy. In earlier legal systems, this conduct was treated as an independent and specifically defined criminal offence, in which the purpose of the act—coercing a person into marriage—constituted a central qualifying element. Accordingly, the legal assessment more explicitly reflected the social reality in which coercion related to marriage was perceived as a distinct legal harm requiring separate criminalisation.

In contemporary criminal law, however, there is a partial abolition or integration of this specialised approach into general criminal offences, particularly within the provision on unlawful deprivation of liberty. This shift may be characterised as a form of "declassification," whereby abduction for the purpose of marriage is no longer explicitly recognised as a distinct legal category, and its identification largely depends on judicial interpretation.

This process is accompanied by the omission of the element of marital purpose from the doctrinal structure of the norm. In modern formulations, emphasis is placed on the fact of deprivation of liberty, while the purposive intent of the act—coercion into marriage—is not directly included as a determinative element of legal qualification. As a result, the specific nature of abduction for marriage purposes is absorbed into the general offence framework, thereby reducing its legal visibility.

This tendency creates a doctrinal imbalance between historical and contemporary regulatory approaches and raises the question of whether the current model adequately ensures the comprehensive and effective criminalisation of all forms of coercion related to marriage.

Doctrinal Problem: The "Purpose Gap"

One of the central doctrinal problems in the regulation of abduction for the purpose of marriage is the so-called "purpose gap"—the legal disappearance or insufficient reflection of the purposive element within the structure of the criminal norm. This term describes a situation in which the purpose of the act,

which in fact defines its socio-legal essence, is not integrated as an essential or qualifying element of the offence.

The current doctrinal model of unlawful deprivation of liberty is generally focused on the fact of restriction of liberty; however, it does not systematically incorporate the purpose of the act—namely, coercion into marriage. Consequently, abduction for the purpose of marriage loses its specific legal identity and is subsumed under a general category of criminal conduct.

The "purpose gap" is particularly problematic in cases where the purpose of the act is not merely a subjective motive but a defining factor of its social significance. In the context of forced marriage, the purposive element determines both the gravity of the act and its degree of social danger, as it is directly linked to the systemic violation of personal autonomy and free will.

Thus, the omission of the element of purpose creates a doctrinal lacuna that affects both the consistency of legal qualification and the effectiveness of practical legal protection (Giorgadze, 2022). This gap constitutes one of the key arguments in favour of the need for a more specialised and clearly articulated criminalisation of coercive acts related to marriage.

Forced Marriage and Minors – Scope of Criminalisation

Forced marriage in criminal law refers to the coercive facilitation of marriage against a person's will, aimed at substantially restricting individual autonomy and freedom of choice (Georgia, 1999; UNODC, 2022). Article 150¹ of the Criminal Code of Georgia specifically criminalises forced marriage, defining it as compelling a person to enter into marriage through violence, threats, or other forms of coercion. This offence acquires particular significance in the context of the protection of minors, as in this group the formation of will, exposure to social pressure, and influence of cultural practices are often more intense, while the need for legal protection is correspondingly higher.

Nevertheless, the current scope of criminalisation of forced marriage is not entirely coherent or comprehensive. The normative framework is primarily oriented toward overt forms of coercion—physical violence, threats, or other direct mechanisms of influence (Kopaleishvili, 2021). In practice, however, forced marriage often manifests in more subtle and structural forms, particularly in the case of minors, where the social environment, familial influence, and cultural traditions play a significant role.

In this context, a particular problem arises from the fact that forced marriage involving minors does not always fall clearly within the established framework of the offence. Specifically, in cases where elements of formal violence or threats are not clearly identifiable, but real pressure or absence of genuine consent exists, legal assessment often remains inconsistent.

As a result, the existing scope of criminalisation creates an asymmetry of protection with regard to minors. On the one hand, legislation recognises their particular vulnerability; on the other hand, it does not fully capture all social and informal mechanisms that may in practice shape consent to marriage under coercive conditions.

Thus, the limited scope of criminalisation indicates a systemic need to reconsider the doctrinal construction of forced marriage in a way that effectively encompasses both overt and subtle forms of coercion, particularly for the purpose of strengthening the protection of minors.

The Problem of Minors' Consent and Subtle Forms of Coercion

One of the most complex doctrinal issues in the context of forced marriage concerns the legal assessment of a minor's consent. In criminal law, consent is generally understood as the free and informed expression of a person's will; however, in the case of minors this category is inherently problematic, as their psychological, social, and legal status often precludes the capacity to make fully autonomous decisions.

In practice, the existence or formal recording of consent is frequently used as an argument for excluding the presence of coercion in marriage, even though the actual formation of will may be significantly influenced by family, community, or traditional social expectations. Consequently, legal assessment in some cases relies superficially on the formal existence of "consent" and insufficiently evaluates the substantive authenticity of that consent.

Moreover, forced marriage cases are particularly characterised by subtle forms of coercion that do not manifest as direct violence or explicit threats. Such mechanisms include psychological pressure, the influence of familial authority, the threat of social isolation, economic dependency, and indirect pressure grounded in cultural norms. These forms often do not meet the clearly identifiable legal criteria of classical coercion, yet they substantially affect the freedom of decision-making of minors.

Accordingly, the issue of minors' consent and subtle forms of coercion presents a significant challenge for criminal law, as the existing doctrinal framework is not fully adapted to a reality in which coercion may be exercised not through overt violence, but through complex structural and social mechanisms of influence.

Engagement/Betrothal of Minors as a "Grey Zone"

The practices of engagement or betrothal of minors represent one of the most complex areas to regulate in the context of coercive marriage-related conduct, as they often exist at the intersection of legal norms and social customs, where legal assessment is neither straightforward nor uniform and depends on both cultural and factual circumstances.

On the one hand, such practices may be perceived as culturally embedded social traditions, regarded in certain ethnic groups as a pre-marital stage of marriage. On the other hand, from a legal perspective, they may contain elements of restriction of a minor's free will,

the pre-determination of a future marriage, and the exertion of social pressure. It is precisely this duality that creates difficulties in legal qualification and often results in fragmented regulatory approaches.

Particularly problematic is the fact that such practices frequently do not fall clearly within the scope of either forced marriage or other classical criminal offences. As a result, the legal system remains limited in its capacity to respond to situations where, although marriage has not yet been formally concluded, a minor's social and personal autonomy has already been significantly constrained.

In relation to ethnic and cultural practices, including traditional forms of engagement observed in certain Azerbaijani communities, these may serve as illustrative examples of how social norms can obscure legal assessment. In such cases, engagement is often perceived as a socially recognised arrangement between families; however, the minor's individual consent and genuine capacity for choice may be substantially restricted (Freedom House, 2023; Council of Europe, 2011).

Accordingly, engagement and betrothal practices involving minors create a legally "ambiguous zone" in which cultural traditions and human rights protection imperatives intersect. The existence of this zone indicates that the current criminal law framework requires a clearer differentiation between formal social practices and genuinely coercive conduct.

Limited Scope of Forced Marriage Qualification and Legal Vacuum

Practices of engagement or betrothal of minors, although often accompanied by elements of social pressure and the pre-determination of future marriage, are frequently not legally qualified as forced marriage. The primary reason for this lies in the doctrinal structure of the offence of forced marriage, which generally requires the actual conclusion of marriage or such clearly coercive conduct that is directly aimed at compelling the act of marriage.

In the case of engagement or betrothal, however, the conduct often remains at a preliminary stage and does not reach the legal threshold required for the qualification of forced marriage. Consequently, even though there may be a real restriction of free will and a pre-definition of the individual's future life trajectory, the existing legal framework is unable to fully identify this process as criminal conduct.

Such an approach creates a significant legal vacuum, as it establishes a space in which certain forms of coercion related to marriage remain outside the scope of criminal liability. This vacuum is particularly problematic in the context of the protection of minors, as it is precisely at this stage that the restriction of their autonomy may begin, while legal intervention is not yet possible.

Although Article 150^1 of the Criminal Code of Georgia provides for forced marriage, its doctrinal construction does not encompass informal pre-marital practices such as engagement or betrothal, thereby creating a regulatory gap (UNODC, 2022).

As a result, the existing framework fails to ensure the "preventive" coverage of coercive processes related to marriage and responds only at a stage when marriage has already been formally concluded or when explicit signs of coercion have become apparent. This reinforces the delayed and incomplete nature of legal protection and ultimately indicates a systemic doctrinal vacuum in this field.

Comparative Legal Analysis of the Criminalisation of Forced Marriage

The doctrinal assessment of coercive practices related to marriage cannot be confined to the framework of national law alone and requires a comparative legal analysis, particularly in light of the standards established under the European Convention on Human Rights (ECHR). Such an approach makes it possible to evaluate whether national regulation complies with the minimum standards of protection recognised within the European legal space and to identify international trends in the criminalisation of forced marriage (UNODC, 2022; Council of Europe, 2011).

First, Article 5 of the ECHR (right to liberty and security) is directly linked to the protection of an individual's physical liberty and imposes on states a positive obligation to ensure effective legal mechanisms against unlawful deprivation of liberty (European Court of Human Rights, 2020). In this context, cases of abduction for the purpose of marriage or other forms of restriction of liberty may be assessed as falling within the scope of state obligations in terms of ensuring effective criminalisation and protective mechanisms.

Second, Article 8 of the ECHR (right to respect for private and family life) is of particular relevance in the context of forced marriage, as it protects individual autonomy in relation to private life, including the freedom to choose whether and whom to marry (European Court of Human Rights, 2020). The case law of the European Court of Human Rights emphasises that any interference with the choice of marriage must be strictly justified, proportionate, and based on the genuine existence of free consent. Accordingly, any form of forced marriage may be regarded as a serious violation of rights protected under Article 8 (European Court of Human Rights, 2020).

The legal approaches of European states demonstrate a growing tendency toward the explicit criminalisation of forced marriage as an independent offence. In several legal systems, including the United Kingdom, Germany, and Scandinavian countries, forced marriage is treated not merely as a consequence of violence or threats, but as a specific criminal offence encompassing both overt and subtle forms of coercion.

Furthermore, contemporary international legal developments indicate a trend toward the unified criminalisation of forced marriage, aiming to consolidate fragmented offences (such as abduction, threats, and coercion) into a single legal concept. This approach seeks to establish a more effective system of protection that better reflects the complex and multi-layered nature of coercion in the context of marriage.

Accordingly, comparative legal analysis demonstrates a clear international tendency toward a more stringent, unified, and systematically integrated criminalisation of forced marriage, which further strengthens the argument for the need for national legal reform (Council of Europe, 2011; UNODC, 2022).

Research Findings

The analysis conducted in this study reveals that the criminal law regulation of coercive practices related to marriage is characterised by systemic and structural fragmentation. The current normative framework does not establish a unified and coherent conceptual model capable of effectively encompassing all forms of coercion related to marriage—both overt and subtle.

First, it was identified that the criminal offences of unlawful deprivation of liberty and forced marriage partially overlap in certain cases, yet they fail to ensure a distinct and unambiguous legal qualification of abduction for the purpose of marriage. This creates doctrinal uncertainty and interpretative inconsistency in practice.

A second significant finding is that protective mechanisms for minors in the context of marriage-related coercion are not sufficiently integrated. Particularly problematic is the legal "invisibility" of informal practices—including engagement and betrothal—which reduces the effectiveness of legal response mechanisms (Freedom House, 2023).

Accordingly, the study confirms the existence of normative fragmentation, which results in unequal and incomplete criminalisation of coercive practices related to marriage, thereby weakening the overall effectiveness of the legal protection system (Georgia, 1999; UNODC, 2022).

The analysis further demonstrates that coercion related to marriage is not conceptualised within the current criminal law as a unified and doctrinally coherent legal object. Its various manifestations—including abduction for the purpose of marriage, forced marriage, and informal social practices—are regulated in a fragmented manner across different offences, which prevents the formation of a unified doctrinal approach. As a result, the overall legal essence of the conduct is disintegrated into separate elements and loses systemic coherence.

In addition, the study identifies that practices of engagement and betrothal of minors remain within the so-called "zone of invisible harm" (Freedom House, 2023). This implies that despite their real impact on a minor's liberty, autonomy, and future marital choice, they often fall outside the direct scope of criminal legal assessment. This creates a situation in which harm exists in practice but remains insufficiently visible in legal terms and therefore receives weak legal response.

Thus, the findings further confirm that the current legal framework addressing coercive practices related to marriage requires a conceptual revision aimed at establishing a unified legal object and recognising the category of "invisible harm" within criminal law (Freedom House, 2023).

Conclusion

The present study has demonstrated that the current criminal law regulation of coercive practices related to marriage does not constitute a systematically unified and doctrinally coherent construct. The fragmented regulation of unlawful deprivation of liberty, forced marriage, and informal practices involving minors creates normative gaps and reduces the overall effectiveness of legal protection.

Under these conditions, the need for a unified doctrinal framework becomes particularly evident. Such a framework would be capable of encompassing the various forms of coercion related to marriage within a single legal category. This approach would not only strengthen the internal coherence of the offence structure but also ensure more consistent and predictable legal qualification in practice.

On the basis of the research findings, it is possible to formulate a recommendation for the development of a unified criminal law model of coercion related to marriage. Such a model should include both overt forms of coercion and subtle and informal practices, including the engagement of minors and mechanisms of social pressure. This would strengthen the protection of minors and reduce the existence of "legally invisible" spaces in which coercive conduct currently remains outside the scope of criminal assessment (Freedom House, 2023).

One of the key directions of the study concerns the necessity of strengthening the protection of minors in the context of coercive practices related to marriage. The analysis clearly demonstrates that minors constitute a particularly vulnerable group both to formal coercion and to subtle social and cultural influences, which requires a higher standard of legal protection (Public Defender of Georgia, 2023). Accordingly, the effective protection of their interests should become one of the central priorities of criminal policy.

Furthermore, the findings of the study clearly indicate the need for legislative reform (Council of Europe, 2011; UNODC, 2022). The fragmented nature of the current regulatory framework and the inconsistent criminalisation of different forms of coercion related to marriage fail to provide an adequate legal response to contemporary social realities. Therefore, it is necessary to reconsider the normative framework and develop it in a direction that ensures the establishment of a unified, coherent, and effective system of regulation of coercive practices related to marriage.

The current provisions of the Criminal Code of Georgia (Articles 143 and 150[1]) do not establish a unified and coherent legal framework capable of ensuring the comprehensive criminalisation of coercive practices related to marriage.

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PEDAGOGICAL SCIENCES

THE USE OF AN ASSESSMENT SCALE AS A TOOL FOR OBJECTIVE TRANSLATION EVALUATION IN LANGUAGE UNIVERSITIES (BASED ON FRENCH LANGUAGE MATERIAL)

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ИСПОЛЬЗОВАНИЕ ШКАЛЫ ОЦЕНИВАНИЯ КАК ИНСТРУМЕНТА ОБЪЕКТИВНОЙ ОЦЕНКИ ПЕРЕВОДА В ПРОЦЕССЕ ОБУЧЕНИЯ В ЯЗЫКОВЫХ ВУЗОВ (НА МАТЕРИАЛЕ ФРАНЦУЗСКОГО ЯЗЫКА)

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Abstract

The article addresses the issue of objective assessment of student translations in translation training. It examines the use of criterion-based assessment scales as a tool for improving transparency and consistency in the evaluation of written and oral translation. Special attention is paid to the role of structured feedback in the development of students' translation competence.

Аннотация

В статье рассматривается проблема объективного оценивания переводов студентов в процессе обучения переводу. Анализируется использование шкалы оценивания, основанной на четко сформулированных критериях, как инструмента повышения прозрачности и последовательности оценки письменного и устного перевода. Особое внимание уделяется роли структурированной обратной связи в развитии переводческих компетенций студентов.

Keywords: translation assessment, assessment scale, translation training, written and oral translation, translation competence

Ключевые слова: оценивание перевода, шкала оценивания, обучение переводу, письменный и устный перевод, переводческие компетенции

В процессе преподавания перевода одной из наиболее сложных задач является объективное и последовательное оценивание переводов, выполненных студентами как в аудитории, так и в рамках самостоятельной работы. Данная сложность обусловлена тем, что переводческая деятельность по своей природе предполагает множественность решений: каждый студент применяет индивидуальный подход, использует собственный стиль, лексический запас и синтаксические конструкции. В отличие от других видов письменных работ, перевод не имеет единственно возможного «правильного» варианта, что значительно усложняет процесс оценивания.

Кроме того, при оценке перевода необходимо учитывать значительное количество критериев, таких как точность передачи смысла, стилистическая адекватность, связность текста, корректность лексического и грамматического оформления. В ходе устного обсуждения или при проверке письменных работ отдельные критерии могут оставаться незамеченными или недооцененными, что приводит к фрагментарной и субъективной оценке. В результате студент не всегда получает полное представление о сильных и слабых сторонах своего перевода, а преподавателю становится сложно обеспечить единый и прозрачный подход к оцениванию.

В связи с этим представляется целесообразным использование шкалы оценивания, основанной на заранее определённых и четко сформулированных критериях. Применение такой шкалы способствует повышению объективности оценки, а также улучшению качества переводов за счёт осознанного подхода студентов к выполнению заданий. В качестве наглядного примера может служить официальная шкала оценивания письменных работ, применяемая при проведении экзаменов DELF/DALF – международный диплом, подтверждающий знание французского языка – которая предоставляется экзаменаторам организациями, ответственными за разработку экзаменационных материалов. Данная шкала отличается прозрачной структурой, четким распределением критериев и баллов, что делает её эффективным инструментом оценивания.

Опыт использования шкал оценивания в рамках международных экзаменов может быть адаптирован для преподавания перевода. Некоторые критерии могут быть сохранены, при

условии их модификации, а также дополнены новыми параметрами, непосредственно связанными с переводческой деятельностью. В зависимости от уровня языковой подготовки студентов и этапа обучения шкала оценивания может варьироваться, однако ряд базовых критериев должен сохраняться.

В рамках настоящего исследования была разработана шкала оценивания перевода на материале французского языка, предназначенная для студентов языковых вузов. В зависимости от вида перевода были предложены отдельные шкалы для письменного и устного перевода. Ниже представлена шкала оценивания письменного перевода:

Grille d'évaluation de la traduction écrite des étudiants		
Critères		Atteint
Compétences pragmatiques	Réalisation de la tâche/Transmission du sens de TO	3
Compétences sociolinguistiques	Adaptation à la fonction de traduction/Respect du ton de TO	2
Compétences linguistiques	Lexique utilisé	3
	Morphosyntaxe	2
		/10
Commentaires de l'enseignant		

С учётом специфики устной переводческой деятельности была также разработана шкала оценивания устного перевода:

Grille d'évaluation de la traduction orale des étudiants		
Critères		Atteint
Compétences pragmatiques	Réalisation de la tâche/Transmission du sens de TO	3
Compétences sociolinguistiques	Adaptation à la fonction de traduction/Respect du ton de TO	1
Compétences linguistiques	Lexique utilisé	2
	Morphosyntaxe	1
Compétence phonétique	Articulation et intelligibilité	2
Gestion de la performance orale		1
		/10
Commentaires de l'enseignant		

К числу основных критериев, прежде всего, относится адекватность передачи информации. Данный критерий предполагает оценку того, насколько точно студент сумел передать смысл, содержание и контекст исходного текста, а также выявление возможных искажений или утраты смысла. Вторым важным критерием является читаемость перевода, включающая связность предложений, логичность изложения и общую целостность текста. Перевод должен восприниматься как завершённый и естественный текст на языке перевода.

Третьим критерием является социолингвистическая адаптация, то есть сохранение стилистических особенностей оригинала и соответствие перевода

коммуникативной ситуации. Студент должен учитывать регистр речи, жанровую принадлежность текста, а также культурные и прагматические особенности. Далее оценивается лексическое наполнение перевода, включающее точность подбора слов, разнообразие словарного запаса и уместность использования лексических единиц. Завершающим базовым критерием является синтаксическая и грамматическая корректность, предполагающая соблюдение правил грамматики и норм построения предложений на языке перевода.

Распределение баллов между критериями может варьироваться в зависимости от системы оценивания, принятой в конкретном учебном заведении. Преподаватель вправе самостоятельно определять значимость каждого критерия, акцентируя внимание, например, на передаче смысла на начальных этапах обучения или на стилистической точности на более продвинутых уровнях. Важным элементом шкалы оценивания является наличие раздела для комментариев преподавателя. Индивидуальные замечания и рекомендации позволяют студентам лучше понять допущенные ошибки и наметить направления для дальнейшей работы.

Помимо самой шкалы оценивания, дополнительные комментарии и советы преподавателя могут служить важным мотивационным фактором. Комментарии помогают студентам ориентироваться в процессе обучения, осознавать собственные трудности и концентрировать внимание на конкретных аспектах перевода. При систематическом использовании шкалы оценивания со временем становится заметен прогресс в качестве переводов, поскольку студенты получают своего рода «инструкцию» или «гид», направляющий их работу и способствующий развитию переводческих навыков.

Для ознакомления студентов с принципами оценивания целесообразно подготовить презентацию, в рамках которой проводится анализ перевода и демонстрируется процесс его оценивания на конкретных примерах. В качестве практического задания во время занятия студентам можно предложить выступить в роли преподавателя: оценить два перевода, подготовленных преподавателем, либо сравнить оригинальный текст с переводом, заимствованным из открытых источников. Студенты могут предложить собственные комментарии и аргументировать выставленные оценки. Данное задание может быть организовано как индивидуально, так и в групповой форме, что способствует развитию критического мышления и аналитических навыков.

Интерактивный характер подобных заданий делает процесс обучения менее формальным и более вовлекающим. Таким образом, оценивание становится не только контрольным, но и обучающим инструментом.

Следует отметить, что предложенный подход применим не только к письменному, но и к устному переводу, с учётом определённых модификаций критериев. В случае устного перевода дополнительно подлежат оценке такие параметры, как произношение, темп речи, психологическая подготовка, использование жестов, а также умение эффективно вести записи. При этом принцип предоставления развернутых комментариев после выполнения задания сохраняет свою актуальность.

Таким образом, использование шкалы оценивания в процессе обучения переводу позволяет систематизировать процесс проверки работ, повысить объективность оценки и создать прозрачные условия для развития переводческих компетенций студентов. Шкала оценивания в сочетании с развернутыми комментариями и интерактивными заданиями способствует формированию осознанного подхода к переводу и повышает эффективность учебного процесса.

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METHODS OF ENGAGING STUDENTS IN TOPICS RELATED TO THE "BIOLOGICAL PROCESSES" CONTENT LINE

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Abstract
The article emphasizes the necessity of education shifting from traditional methods to a more dynamic and interactive format against the backdrop of modern technological challenges. The success of a lesson depends on how students are engaged in the process from the very first minutes—that is, on the proper building of motivation and interest. To activate students, it is recommended to create problem-based situations and utilize methods such as analogies, visual aids, real-life examples, and the integration of technology

Keywords: biological processes, cognitive activity, interactive teaching methods, content line

The world is changing at a pace unprecedented in previous eras. This transformation profoundly influences the lifestyle, values, and worldview of modern individuals — including students. Given that many students spend the greater part of their day engaged in dynamic, technology-driven activities involving computers and mobile devices, organizing the teaching and learning process in traditional ways has become increasingly impractical. Adapting instruction to fit this new environment is no longer optional — it is a necessity.Engagement means arousing interest in any given activity. The material and moral benefits a person expects from their work serve as motivating factors. Motivating students toward learning, sparking their interest in the subject matter, and drawing them into the process by showing the intended outcome in advance — these are the core components of student engagement. Engagement is also a form of activity that actively draws students into the lesson on the basis of cognitive effort. In this context, researcher Robert Philips coined the phrase "hooking the student" — meaning that the lesson must be structured from the very beginning in such a way that students can fully direct their attention and curiosity toward the content. When the engagement process is properly designed at the start of a lesson, it not only draws students in actively but also creates the conditions for the remainder of the lesson to be successful. One of the key points a teacher must attend to is ensuring that all students in the classroom are included in the learning process. It is not uncommon to observe that while the majority of students participate actively, some others remain disengaged.

There are various reasons why students may fail to engage actively in lessons. Among the most common are the following:

- failure to understand the question or task;
- being overlooked by the teacher;
- family or domestic problems at home;
- social withdrawal or introversion;
- ineffective organization of classroom activities.

Observations suggest that teachers often design introductory activities around guessing the topic of the lesson — activities that take on a puzzle-like character. Limiting the engagement phase to merely identifying the lesson topic is a misguided approach. Instead, this phase should direct students toward the intended learning outcomes and genuinely arouse their curiosity about the subject matter.

Creating a problem situation at the beginning of the lesson is an effective way to engage students. A range of techniques can be employed toward this end:

- **Presenting a problem:** Introduce a problem connected to the lesson content. This can generate curiosity and motivate students to investigate and seek solutions.
- **An engaging opening:** To capture students' attention, teachers can begin the lesson with a surprising fact, a relevant quotation, a crossword puzzle, a thought-provoking question, or a brief anecdote.
- **Provocative questioning:** Opening with a question that stimulates critical thinking and encourages students to reflect on the upcoming content can be highly effective.
- **Visual tools:** Multimedia resources such as short videos or compelling images related to the lesson topic can be used. Visual materials capture students' interest and create a readiness for learning.
- **Personal experience:** Sharing a personal story and connecting it to the lesson material can make the content more relevant and relatable for students.
- **Use of music:** Playing a brief piece of music related to the lesson topic can evoke emotions and help create a positive classroom atmosphere.
- **Icebreakers:** Quick, interactive activities that encourage students to share something about themselves or interact with peers can help lower barriers to participation.
- **Clarifying lesson objectives:** Clearly stating the goals of the lesson from the outset increases student engagement and helps set expectations.
- **Technology integration:** Interactive polls, quizzes, and online tools can be incorporated into the introductory phase of the lesson to encourage participation.
- **Physical movement:** Short physical activities that energize students and help them focus can be particularly effective during transitions between topics.
- **Connecting to the previous lesson:** Beginning with a brief review of the prior lesson helps

students recall information and prepares them for new material.

- **Demonstrating enthusiasm:** Teachers should approach the lesson with genuine enthusiasm. Attitude is contagious — a teacher's passion for the subject directly influences student engagement.

Experience shows that one of the main reasons students are not actively engaged throughout the lesson is that they were not meaningfully drawn in at the very beginning. This, in turn, leads to lower academic achievement. When students are effectively engaged at the start of the lesson, the overall learning process becomes considerably more successful.

Interactive teaching methods are among the most effective approaches for ensuring students' active participation and developing their knowledge and skills. Their application is particularly significant within the "Biological Processes" content strand in Grade 8. Since biological processes are often theoretical and complex, methods such as thought-provoking questions, brainstorming, clustering, concept extraction, role-playing, discussions, and simulations can be used to actively engage students in the learning process. The analogy method yields strong results when teaching "The Human Nervous System and Its Reflex Function." The essence of this method lies in comparing the body to an orchestra and the brain to its conductor. Students are prompted to consider: If the brain did not exist, which processes would cease in the organism? If the brain controls all organs, what controls the brain itself?

Another application of analogy involves comparing the human skeletal system to the chassis of a robot. Students explore the following scenario: A robot needs a sturdy frame to function and move — so how does our body work? What might serve as the body's "frame"? Just as robots have metal structures, our bodies are supported by bones. This motivational approach directs students to discover the components that enable bodily movement.

Thought-provoking questions delivered through brainstorming can be highly effective. For example, when introducing the topic of respiration, the following prompt can be used: "Take a deep breath right now. The air has entered through your nose — but where does it go? Which pathways does it travel through? Where does it pause? And what work does it ultimately carry out? Let us together embark on the remarkable journey of a single breath through the human body!" Questions of this kind generate genuine curiosity and draw students deeply into the topic.In teaching topics within the "Biological Processes" strand of Grade 8, the use of visual tools — including illustrations, video materials, and animations — increases students' interest and makes lessons more memorable and interactive. For instance, when covering "Lungs, Respiratory Movements, and Gas Exchange," students can be shown a comparative illustration of the lungs of mammals and amphibians, followed by the question: In what ways do the lungs of mammals differ from those of amphibians? How is gas exchange carried out in each organism?

The use of real-life examples helps students develop a deeper understanding of biological processes. Such examples make abstract concepts concrete, enabling students to draw connections between classroom content and everyday experiences. For instance, when explaining respiration, referencing the acceleration of breathing during physical exercise gives students a tangible point of reference. When students see how what they are learning applies in real life, they find the information more meaningful and retain it with greater ease. Furthermore, reflecting on real-life examples develops their critical and creative thinking skills.

The application of interactive teaching methods significantly enhances student engagement, particularly in teaching complex and theoretical subjects such as biology. Through analogy, brainstorming, visual tools, real-life examples, and problem-based situations, teachers can cultivate intrinsic motivation in students. Transforming students into active participants from the very beginning of the lesson ensures the success of all subsequent teaching stages, improves academic achievement, and creates the conditions for more durable and meaningful learning.

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PHILOLOGICAL SCIENCES

ELCHIN'S PERSPECTIVES ON LITERARY CRITICISM

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Abstract

The aim of the article is to clarify Elchin's literary-critical ideas as a professional critic. Elchin is also known as a writer in the literary process. Therefore, there is an approach to his activity from the position of writerly criticism. This does not reflect the truth. Such approaches contradict the essence of objective criticism. Because his scientific-theoretical conclusions distance him from writerly criticism. The critical ideas in his research correspond to the essence of professional criticism. This approach, critical judgment also forms the basis of his artistic creativity. He approached social phenomena from an objective aspect, discovered both beauty and negative aspects, and was able to reveal them, touching upon vivid events that make the reader think. The sense of responsibility in his artistic creativity has equally continued in his scientific activity. At the junction of artistic thought and critical thought, the personality of a writer and critic has been formed.

In Elchin's monographs and articles, the creative and methodological issues of Azerbaijani literary criticism, the tasks of modern criticism, the current problems of the literary process, the development directions of the history of criticism and its aesthetic features, and the potential possibilities of Azerbaijani literary criticism have been the object of research. He should take his place as a professional critic among critics such as Mirza Fatali Akhundzade, Kamal Talibzadeh, Mikayil Rafili, Gasim Gasimzade, Mammad Jafar Jafarov, Mammad Arif Dadashzade, Yashar Garayev, Masud Alioglu, Akbar Aghayev, Qulu Khalilov, Bakir Nabiyev. The scholar, who involves both criticism and prose in mutual research, has drawn attention to the importance of critical thought in the development of prose, and issues such as modernity, tradition and innovation, and character have been revealed in the dialectical unity of criticism and prose. The critic, who gives importance to the study of modern and classical heritage, has not left aside the problem of historicism and modernity in literature.

As a result, we conclude that Elchin holds the view that literary criticism is an expression of professionalism. The critic has based his work on methodological principles.

Keywords: criticism, professional critic, modernity, literary process, prose

Introduction. Thought, freedom, responsibility, and objectivity - these are essential elements in all areas of literature and literary studies. However, in literary criticism, the attainment of these concepts as independent principles is particularly significant in terms of addressing the assigned topic and problematics. Debate surrounding the question, "Can criticism that activates thought and demonstrates creative principledness fulfill its duties?" continues to prevail within the literary process. The primary reason for this lies in the responsible approach to intellectual freedom. The existence of criticism is only possible through the critic's freedom of thought. Unfortunately, it must be noted that representatives of writerly criticism and professional criticism have often prioritized ideology over free thought. "Rather than offering an escape from ideology, then, literary texts may be considered as places where the structures and fractures of ideology are both produced and reproduced. Literary texts do not simply or passively "express" or reflect the ideology of their particular time and place. Rather, they are sites of conflict and difference, places where values and preconceptions, beliefs and prejudices, knowledge and social structures are represented and, in the process, opened to transformation" (Andrew, B.; Nicholas R, 2004, p.177).

In fact, ideology represents a starting path for development. It embodies a system of shared ideas, common convictions, and collective values. Whether in politics or in artistic creation, it serves the purpose of directing consciousness and preserving beliefs. Ideology has always existed in literature; however, its most prominent manifestation falls within the Soviet period. If we examine the historical stages from the twentieth century to the contemporary era, we observe that in literary criticism the early decades of the century were dominated by the ideology of nationalism, the period from the 1920s to the 1990s by socialist ideology, and the years of independence by liberal ideology.

At the beginning of the twentieth century, the confrontation of ideologies was manifested in the example of the journals "Molla Nasreddin" and "Füyuzat". In Soviet literary criticism, the presence of persuasion, the subordination of the primary objective to collective psychological equilibrium, and the legitimization of the dominant worldview demonstrate that criticism remained faithful to a regime of ideological monism within political consciousness.

However, it is also a fact that the most active period of Azerbaijani literary criticism is associated with Soviet literature. In a period when ideology was dominant, professional criticism occupied a leading position. Elchin is a figure in critical thought who serves a liberal ideology. His criticism is fundamentally grounded in free thought.

Literary criticism, one of the important branches of literary studies, has the capacity to influence the activity of creative personalities and to shape aesthetic taste. This, in turn, is a dimension that serves the development of artistic creativity. Moving away from descriptive articles and orienting itself toward objective evaluation, the primary task of criticism is to approach literary works from the standpoint of scientific values. The ability to penetrate the depths of the psychology of creativity is an essential factor for a critic. The quality of criticism depends on the level of justification of the evaluation given to the analyzed work. Just as the concept of criticism is a leading feature in various spheres of society, in literary studies professional criticism must also maintain its dominant position. In this regard, the distinction between writerly criticism and professional criticism emerges as a defining feature. In certain cases, literary figures, through their creative work and scientific-theoretical conclusions, embody both the writer and the critic within their personality. Among such figures, the creative activity of Mirza Fatali Akhundzade, Seyid Huseyn, Mir Jalal Pashayev, Mehdi Huseyn, Mirza Ibrahimov, and Elchin may be noted. The primary target audience of both the author of a literary work and the researcher evaluating that work is the readership. Therefore, their activity is oriented toward a single purpose: guiding the aesthetic taste of the reader in artistic creativity toward aesthetic criteria and combining aesthetic judgment in critical thought with critical reflection.

In the analysis of a work, a writer, creative activity, and critical ideas, the presence of methodological precision creates conditions for the development of criticism and for the literary process to continue in a proper direction. Hesitation and the weakness of polemical force make it difficult to establish standards and criteria. Vaqif Yusifli has clarified the question of what kind of critic Elchin is as follows: “Although Elchin’s polemics sometimes attract attention in a harsh and excessive manner, they are free from personal bias, gossip, and malicious intent. And, most importantly, he substantiates his ideas and opinions with sufficient theoretical preparation and a critical way of thinking” (Yusifli V., 1999, p.227).

Elchin has succeeded in providing a methodological approach to the systematic solution of the problems raised in his criticism. In his research work “Criticism and Prose”, while studying the relationship of literary criticism of the years 1945–1965 with prose, he did not follow a chronological method; instead, he traced the literary process through its problematic issues. Although he did not conduct a strict periodization, the study, in terms of its thematic structure, addresses interrelated and successive issues. In the introduction of his research, Elchin provides information about his methodological mastery and explains the scientific-logical approach underlying the problems he raises. Elchin’s criticism is distinguished by its conceptual nature. In his approach to prose within criticism, he addresses the problems of modernity and character from the standpoint of tradition and innovation. The critic, who writes that “Where there is no modernity, there is no art” (Elchin, 2005, p.228), analyzes the logical implications of these ideas and interprets them, directing his thought toward the formation of new ideas.

In literary works, it is relatively easy to clarify the degree to which the category of modernity is employed. A critic’s ability to comprehend this concept, to introduce a work into the literary process, and to adopt a specific critical position toward it remains an issue of enduring relevance in all periods. Regardless of whether works are written about the recent or distant past, those that are required by present generations, that respond to contemporary demands, and that serve the future development and interests of humanity constitute the core of the content of the category of modernity. In other words, the concept of modernity encompasses not only contemporary writers but also writers of past and ancient periods who carry a modern spirit. Modernity is not limited to literary works alone; it is also related to the critic’s ability to perceive the present time and to possess a deeply reflective literary-critical mind. “Criticism is always contemporary and always serves modernity. In the influence that modernity exerts on moral and spiritual quests, the moral value, impact, and authority of criticism itself are expressed. In every period, criticism assumes responsibility for the moral perfection of the reader and of art as a whole. The work performed by criticism as an act of artistic-aesthetic consciousness, as the ‘moral conscience’ of art, consists precisely in this function. Life becomes aware of itself in art, and art becomes aware of itself in criticism” (Garayev Y., 1981, p.186).

In Elchin’s analyses, there is a clear attempt to elucidate the manner in which criticism approaches modernity. The quality of modernity in Elchin’s work requires an innovative attitude from the critic toward reality and creativity. The novelty of criticism also depends on the quality of the literary material. Elchin has also not overlooked the influence of those who indulge in superficial literary attitudes or prefer a “telegraphic style” within the literary process. “The main significance of art consists in reflecting what is of interest to human existence. However, while being interested in the phenomena of life, a person cannot, consciously or unconsciously, avoid passing judgment on these phenomena. A writer or artist, as a human being, cannot avoid judging the phenomena being depicted” (Chernyshevsky N., 1956, p.128).

The existence of characters who carry the aesthetic ideal of an epoch, embody progressive ideas, and are capable of making them comprehensible may guide criticism itself. Criticism is not a one - sided process; its foundation, methodological inquiry, and aesthetic problems are formed on the basis of literary material and the critic’s individual style. It is also the literary material that brings an innovative spirit to the critic. A work that corresponds to life, as well as its analysis,

shapes the category of modernity. Elchin noted that "the reader wanted to see in the works they read the artistic-philosophical reflection of innovations and development in life, and their interpretation at the same level - if it is a work of art, in an artistic form; if it is a sample of literary criticism, in a scientific-philosophical form" (Elchin, 2005, p.170).

A critic is a reader who possesses scientific knowledge, the capacity for philosophical generalization, and the responsibility of evaluation. However, unlike that of an ordinary reader, his assessment is not the product of initial impression or subjective judgment; rather, it is the result of free thought that connects artistic truth with the contemporary era. In Elchin's studies, this line of thought is directed toward analytical investigation based on facts. In other words, he is not a descriptive critic but an applicative one. Thus, when contrasting the concepts of national tradition and literary tradition, he refers to Ilyas Afandiyev's work "The Bridge Builders". Elchin wrote: "National tradition and literary tradition are not identical; although national tradition and literary tradition form a unity, in certain cases they may not coincide. Literary tradition may develop in the opposite direction to national tradition and, as a result, may, over the course of years, contribute to the disappearance of that national tradition. National tradition may develop in opposition to an artificial literary tradition and, consequently, after many years, lead to the elimination and disappearance of that literary tradition" (Elchin, 2005, p.173).

In addressing how criticism responds to a new theme introduced into literature beyond national tradition, he sometimes adopts a hesitant stance, sometimes a courageous one, and at other times challenges subjective views by emphasizing the dynamism of artistic creativity and its openness to innovation: "In contrast to the progressive position of Azerbaijani prose, literary criticism acted from a conservative, and at times even regressive, position" (Elchin, 2005, p.165).

In order to preserve objectivity, the critic must free himself from archaic modes of thinking within his consciousness. In his view, tradition and innovation, although seemingly opposed to one another, do not negate each other; rather, they exist in a dialectical unity in all periods in the name of modernity. "True modernity can be revealed and studied through understanding 'what', that is, what kind of life content is reflected in 'how', through examining the relationship between 'what' and 'how', and through perceiving their harmony" (Mammadov, M., 1968, p.9).

The main characteristic of the category of modernity is connected with the system of artistic images, the typical conditions of unfolding events, the character features of images, and issues of content and form - in short, with the artistic mastery of the literary work. Regarding the issue of character, Elchin's response to the question "What should criticism be like?" is grounded in the existence of critics capable of escaping the grip of ideology and breaking the silence. A critic should not merely analyze the opposition between positive and negative characters; rather, he should demonstrate the competence to express his own attitude toward the writer's characters. "The strength of an artistic image lies in its emotionality and in its possession of aesthetic content. An artistic image is such an aesthetic map in which objective and subjective, particular and general, individual and typical, emotional and rational aspects are firmly and organically united" (Mammadov M., 1975, p.103). In literary evaluation, forgetting the emotional dimension of the literary work and taking sides between positive and negative characters within the author's conceptual framework also affects the quality of objective criticism itself.

At the beginning of the twentieth century, Mammad Said Ordubadi opposed those who propagated the idea that "there is no criticism, and poetry and literature should be left to the decree of fate," and he argued: "Our criticism, for the time being, does not possess the inclination toward free thought, independent reflection, and providing literature with an autonomous direction. In the spirit of our criticism, the influence of individual personalities occupies a greater place than the artistic impact of the work to be criticized" (Ordubadi M.S., 1967, p.357). If we turn our attention to the contemporary period, controversial opinions regarding the failure of criticism to fulfill its functions still prevail. On this issue, Elchin stated: "There is Azerbaijani literary criticism, about which complaints are heard; its level and condition cause concern for some" (Yusifli V., Yusifli C., 1999, p.215).

Thus, expectations regarding criticism have always existed and will continue to exist, because the application of theoretical thought in the literary process is not uniform. Criticism develops along a historical trajectory, while attention to theoretical and practical aspects is often pushed into the background. Criticism becomes a tool that deliberately sacrifices its modernity to historicism and subordinates the evaluative thought derived from the quality of the literary work to the status of the writer. Criticism exists, yet its essence has changed. Critics exist, yet critical erudition remains weak. The critic's anxiety noted by Yaşar Garayev, the critic's responsibility advocated by Elchin, and the realization of the critic's freedom that we demand will ensure the development of criticism on its proper foundations.

A distinctive feature characterizing Elchin's style is the figurative expression of thought. This mode of expression serves to convey ideas in a vivid and dynamic manner within scholarly discourse. Aesthetic value is a driving force of criticism; therefore, such a style influences aesthetic perception and ensures that ideas are more easily retained in memory. In the critic's formulations, the research objective is presented in a fully vivid manner, while emotional nuance is intensified. Such an analytical approach aims both to stimulate thought and to evoke emotional response. A function of concentration is also evident. Using metaphor, he compares the formation of a literary work to the development of a tree: "A tree itself is a literary work. It has countless branches, large and small: the laws, genres, style, form, architectonics, structure of

literature; the idea, philosophical, aesthetic, and ethical concepts served by the writer; his worldview, position, writing culture, artistic mastery, and so on. On these branches there are various delicate leaves: features that make the literary work aesthetically refined and intellectually meaningful. However, both these branches and leaves rest upon the trunk, which is their support and source of nourishment. The roots are talent. The roots absorb nourishment from the soil. The soil is life, and nourishment is themes" (Elchin., 2005, p.228). This feature does not merely characterize the individuality of his expressive style; rather, it demonstrates that the critic's manner of writing stems from the methodology of criticism itself.

Conclusion. By examining Elchin's position in the literary process and his creative qualities as a figure who develops contemporary critical thought from a methodological perspective, the differences between writerly criticism and professional criticism have been brought to light. The methodology in Elchin's criticism is subordinated to the general principles of literary criticism. At the same time, through his critical ideas, he has revealed his individual creative qualities. The writer embodies two interconnected characteristics within the Azerbaijani literary process: that of a writer and that of a professional critic. In his artistic creativity, critical judgment is also present. This is precisely the feature that characterizes his criticism. In other words, this talent is dominant throughout his overall creative output. In his literary works, artistic expression is fundamental, whereas in his critical ideas, scientific-theoretical thought constitutes the main basis. Elchin is among the critics who continue, in the contemporary period, the tradition of the professional school of literary criticism that began with Mirza Fatali Akhundzade. What distinguishes him from other critics is his adherence to the concept of modernity in criticism. His attempt to define the differences between literary tradition and national tradition is directed toward clarifying the concept of modernity. At the same time, his analyses have the capacity to guide the literary process, while critical reflection possesses the power to shape public opinion.

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THE ROLE OF ENGLISH IN MEDICINE: HISTORICAL EVOLUTION AND IMPACTS ON EDUCATION

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Abstract

In the realm of modern medical science, the English language has emerged as the primary lingua franca, fundamentally facilitating the global exchange of clinical knowledge and research findings. This article aims to analyze the historical evolution of English in the medical field, and to evaluate its current impact on medical education and professional development. Utilizing a mixed-methods research design, a comprehensive survey was conducted among medical students at Nakhchivan State University, Faculty of Medicine. The results demonstrate a clear recognition of the language's importance, with a significant majority of participants (65%) identifying English as an essential prerequisite for professional success in the modern era. Furthermore, while 85% of respondents engage with English-language medical resources to varying degrees, the study identifies persistent obstacles, most notably the difficulty in mastering complex medical terminology and a deficiency in writing and listening proficiency. The findings suggest that while a minority remains hesitant toward linguistic homogenization, the role of English as a "language bridge" is indispensable for rapid scientific exchange. The study concludes that as communication barriers decrease, the pace of medical innovation accelerates, making English proficiency a vital component of contemporary medical training and global healthcare integration.

Keywords: lingua franca, medicine, language, English, evolution

Introduction

In recent years, English has played an important role in many fields. Today, the majority of medical textbooks, scientific journals, clinical guidelines, and online educational resources are published in English. As a result, English has become an essential tool for the exchange of medical knowledge across countries and cultures. In order to become future physicians, medical students must not only acquire medical knowledge but also be able to communicate effectively in English, which is widely used for professional purposes and is often considered a common language [3].

The rapid development of medicine requires healthcare professionals to stay updated with the latest discoveries, treatment methods, and research findings. Since most new information first appears in English-language sources, proficiency in English enables doctors, researchers, and students to access current evidence without delay [11]. This helps improve patient care, encourages innovation, and supports evidence-based medical practice.Since most new information first appears in English-language sources, proficiency in English enables doctors, researchers, and students to access current evidence without delay. This helps improve patient care, encourages innovation, and supports evidence-based medical practice. Thus, it can be said that the English language paves the way for collaboration and innovation in the field of medicine. To understand its present importance more clearly, it is necessary to examine how English gained this influential position throughout history and how it continues to shape modern medical education [8].

Main body

The development of medical English is not a direct process; rather, it is a complex transitional evolution involving multiple languages.

This language, which began to take shape under the fundamental influence of ancient Greek medical traditions and the Latin language, underwent a process of Latinization of terminology during the Roman Empire. In the Middle Ages, it was further enriched through the mediation of Arabic and French, eventually becoming the modern lingua franca.

In ancient Europe, Greek was the most influential language in the development of medicine, and until the fall of the Roman Empire, it served as the language of physicians in medical schools [7]. While in Ancient Greece the scientific language was distinct from the common language, in Ancient Rome a new phenomenon emerged the development of bilingual Greek-Latin terminology. Later, during the Middle Ages, as a result of the conquest of England by French-speaking populations, medical terms of Latin origin began to enter the English language not directly, but through French [4].

In the post-Renaissance period of the English language, one of the most important issues was its standardization, as there were significant differences between its spoken and written forms. This process was largely achieved through the development of dictionaries, beginning with Dr. Samuel Johnson's two-volume A Dictionary of the English Language, published in 1755.

Today, the majority of words used in English originate from Latin and Greek. Statistical analyses conducted by Andrews (1947) indicate that approximately 80% of the English scientific lexicon is derived from classical languages [7].

Although in the past medical English relied on Greek and Latin to create new terminology, modern English increasingly utilizes its own linguistic resources and also influences the language systems of other nations [2]. In earlier periods, newly introduced medical terminology was typically formed from classical Greek or Latin roots. However, in contemporary usage, such terms are often partially or entirely derived from everyday English vocabulary for example, bypass operation, clearance, base excess, screening, and scanning. As a result, medical professionals in non-English-speaking countries may either adopt these terms directly or translate them into their native languages [17].

Global health communication refers to the scientific and creative methods used to inform individuals from the general public to government officials and to encourage them to make healthier decisions [10]. The primary aim of this process is to improve people's well-being and enhance health-related outcomes. The main objectives of global health communication include raising awareness about diseases, encouraging individuals to adopt healthier lifestyles, and promoting appropriate policies that support global health standards.

However, certain challenges may arise in global communication [1]. For example, medical terminology may be inaccurately translated into local languages, and specific medical recommendations may be interpreted differently across cultures [9]. In the modern era, information and communication technologies have become one of the most important components of global health. Electronic and mobile health have enabled people to access medical information more easily. However, these technologies can sometimes create barriers in the communication process; one such example is the rapid spread of misinformation on social media platforms [5]; [16]. Therefore, in order to establish effective global health communication, it is essential to both utilize technological innovations and respect cultural sensitivities [6].

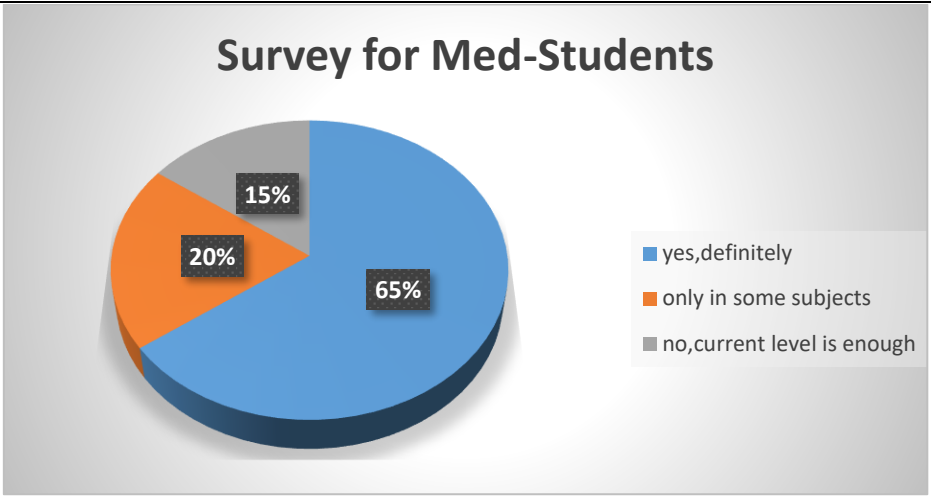
English is considered the most effective and widely used medium of global communication. Particularly in the field of medicine, the sharing of new discoveries, clinical research, and scientific findings is largely conducted in English [15]. As a result, researchers and professionals who lack proficiency in this language may, to some extent, remain excluded from the global scientific community.

Finally, English is not only a means of communication but has also become one of the key drivers of development and innovation. It strengthens global collaboration and facilitates the exchange of information among professionals who speak different languages.

Results and discussion

Taking into account all the facts discussed in other articles, we decided to conduct a survey among the students of our university to expand the knowledge of medical English. 20 people participated in the survey. In total,5 questions were presented to the participants. The participants were asked whether they believe English is essential for success in modern medicine. As expected, the 'Yes, of course' option was the most frequently selected response, accounting for 75% of the total. Only two person out of 20 people chose not 'no,not necessary'. On the other hand, the 15% of participants who viewed English as less critical chose the response 'Partly important'. The second question, aimed at assessing students' engagement with English-language materials, asked: 'How often do you use English medical resources in your studies?' Regarding the responses, the majority of participants chose the 'Sometimes' option, indicating that they utilize English resources to some extent; the indicator for this answer constituted 85%. Two participants, representing 10% of the sample, reported that they do not use English resources at all, while only one respondent frequently utilizes these materials. "In response to the question, 'Do you think the global use of English has accelerated the development of medicine?', the majority (60 percent) answered 'Yes' with confidence. One respondent chose 'No,' while the remaining participants opted for 'To some extent.' In my view, the latter is the most accurate perspective, as the language acts as a bridge, facilitating communication between people of different linguistic backgrounds. Naturally, the easier the communication, the more rapid the exchange of ideas becomes. Furthermore, the fourth question addressed the potential challenges students might encounter with medical English. As expected, the most significant obstacle identified by students is understanding terminology across different languages. Additionally, some respondents highlighted the difficulty of using foreign resources and noted a lack of proficiency in writing and listening skills. I am presenting the fifth question, which is the main question directly related to our article. The question is : Should English be given more importance in medical education programs?

Pie chart 1. Survey for med-students



While 65% of respondents selected the 'Yes, definitely' option, some individuals remain reluctant to prioritize English, despite its numerous advantages. Additionally, the 20% of students within the mid-range believe that maintaining an average level of focus is the best approach.

To complement the survey results, a semi-structured interview was conducted with a surgeon at Azerbaijan Medical University, who is also involved in teaching activities, Gunel Khalilova. The interview focused on the importance of English language proficiency in medical practice.When asked about the importance of English for following the latest research and clinical protocols, the participant emphasized that it is essential. She noted that *most accessible scientific articles and protocols are available in English, while resources in the native language are very limited.* She further stated that*, although translation may be provided during international conferences, understanding information directly from the original source is significantly more effective than relying on interpretation.*

Conclusion

In conclusion, it can be said that medicine is not only confined within national borders but is also one of the most important The conducted analyses show that practice-oriented education tailored to students' needs not only increases their motivation but also contributes to the development of their professional skills [14].Thus, the fields developing rapidly on a global scale. In order to protect human health and improve quality of life, it is essential to pay special attention to this field and follow innovations that lead to positive advancements [12]. Medical education in English is one of the key directions of this innovation and serves as a bridge between specialists from different countries. For students who wish to study and specialize abroad, learning this language is essential skills in medical education, along with training in medical translation, contributes positively to healthcare communication and plays an important role in enabling healthcare professionalsto perform successfully [13].

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LANGUAGE, COGNITION, AND IDENTITY IN MOTION: HOW LINGUISTIC EXPERIENCE SHAPES THOUGHT AND THE SELF IN MULTILINGUAL LIVES

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Abstract

Language is not only a tool for communication; it is also a cognitive environment and a social resource through which people organize experience and construct identity. Recent research shows that linguistic experience can shape attention, self-evaluation, and decision-making, while also influencing how speakers understand belonging, heritage, and professional selfhood. At the same time, cognitive science has been criticized for relying too heavily on English-speaking participants, which narrows the scope of conclusions about human cognition [1]. This article offers a brief integrative review of post-2020 research on the relation between language, thought, and identity. Drawing on studies of bilingual cognitive reserve, bilingual attention, multilingual language attitudes, heritage language identity, self-evaluation in bilingual adults, and language-based clustering in organizations, the article argues that language should be understood as a dynamic system rather than a neutral code [2-6]. The evidence supports a moderate position: language does not mechanically determine thought, but it can shape habitual cognition, emotional distance, and social self-understanding. In multilingual lives, speakers continually move between linguistic frameworks that affect how they think, judge, and present themselves. This makes language central not only to linguistics but also to cognitive science and identity research [1-6].

Keywords: Bilingualism, Cognitive Science, Language and Identity, Multilingualism, Linguistic Relativity.

Introduction

The relationship between language, thought, and identity remains one of the most important questions in linguistics. Recent research has moved beyond the older idea that language simply reflects pre-existing thought. Instead, scholars now examine how different languages may guide attention, memory, judgment, and self-concept in subtle but meaningful ways [1,2]. This is especially visible in bilingual and multilingual contexts, where one speaker may use different languages in family life, education, and work, and each language may carry distinct emotional and social meanings [4-6].

A major development in this area is the critique of English-centered research. Blasi and colleagues argue that the dominance of English speakers in cognitive science has biased the field and limited generalizations about the human mind [1]. Their point is not only methodological. It also suggests that language itself matters for cognition in ways that are easy to miss when research is restricted to one linguistic ecology. At the same time, bilingualism research has increasingly focused on cognitive reserve and attention, showing that language experience may contribute to resilience and shape attentional processing without producing a simple universal "advantage" [2,3].

Identity research leads to a similar conclusion. Heritage language is often tied to memory, family history, and professional aspiration, while language attitudes can shift according to context and social relations [4-6]. In multilingual settings, language is therefore not merely a means of expression; it is part of how people understand who they are. This article develops a concise review of recent findings and argues that language, thought, and identity should be studied together as interconnected dimensions of human experience [1-6].

Language as a Cognitive and Social System

The strongest recent evidence against a narrow view of language comes from cognitive science itself. Blasi et al. show that the field has over-relied on English and that this creates a distorted picture of cognition, because English differs from many other languages in ways that can affect memory, perception, and decision-making [1]. Their review implies that language diversity is not a side issue. It is a source of theoretical insight. If different languages encourage different patterns of categorization and attention, then linguistic experience becomes part of the architecture through which thought is formed [1].

Bilingualism research supports this broader view. Bialystok's review argues that bilingualism may contribute to cognitive reserve, meaning that managing more than one language can help support cognitive functioning across the lifespan [2]. The study does not claim that all bilinguals show the same pattern or that bilingualism produces a universal cognitive bonus. Rather, it shows that repeated language management may have long-term cognitive consequences, especially when viewed across aging and resilience [2]. In parallel, Chung-Fat-Yim, Calvo, and Grundy argue that bilingualism and attention must be understood as multifaceted phenomena. Their review shows that different kinds of bilingual experience relate differently to attention, so the relationship between language and cognition is context-sensitive rather than uniform [3].

These findings support a moderate linguistic-relativity position. Language does not trap thought

inside fixed conceptual prisons, but it can shape how people attend, compare, and evaluate. The cognitive effects of language are therefore best understood as habitual and probabilistic, not absolute [1-3]. This matters because it also opens a bridge to identity research: the same linguistic routines that shape attention can also shape social self-understanding.

Language, Identity, and Self-Interpretation

Language is deeply connected to identity because it carries social meaning. Park, Zong, Polat, and Schallert show this clearly in their study of bilingual/ESL preservice teachers. Using multimodal literacy autobiographies, they found that heritage language experiences were central to how participants formed their language identities and imagined themselves as future teachers [4]. This is important because it shows that language identity is not merely a label. It is something people build through memory, schooling, aspiration, and emotional attachment [4].

A similar pattern appears in organizational contexts. Kalra and Danis show that language-based clustering in multinational enterprises is dynamic rather than fixed. In their study, language intersects with gender, regional dialect, and education to reshape group formation and workplace processes [5]. This demonstrates that language identity is socially embedded. People do not simply "have" a language identity; they negotiate it through institutional settings and social hierarchies [5].

Self-evaluation offers another window into this process. Hernández-Rivera and colleagues found that bilingual adults 'language self-assessments were shaped not only by objective performance but also by language solidarity, especially for value-laden judgments such as how "good" one is in a language [6]. This is a striking finding because it shows that self-knowledge is not purely internal. The language in which people evaluate themselves can change what feels accurate, possible, or respectable [6]. In this sense, identity is partly an effect of language, not just its content.

Taken together, these studies suggest a unified model. Language influences cognition through attention, reserve, and evaluation; it influences identity through heritage, solidarity, and institutional belonging [1-6]. The result is not linguistic determinism, but linguistic mediation. Speakers think through the languages they inhabit, and those languages help organize the social meaning of the self.

Conclusion

Recent scholarship supports a compact but powerful conclusion: language, thought, and identity are inseparable in multilingual life. Research on English bias in cognitive science shows that the field must broaden its linguistic base if it wants to make stronger claims about human cognition [1]. Work on bilingual reserve and bilingual attention suggests that language experience can shape cognitive processing in nuanced and context-dependent ways [2,3]. Studies of heritage language identity, organizational clustering, and self-evaluation show that language also helps construct belonging, confidence, and professional selfhood [4-6].

The most useful interpretation is neither strong linguistic determinism nor complete neutrality. Language does not fully determine thought, but it does influence the routines through which people perceive, judge, and remember. In multilingual speakers, these routines may shift across contexts, producing different emotional and social effects depending on the language being used [2-6]. That is why language should be studied not only as a system of grammar and vocabulary, but also as a medium of cognition and identity.

For future research, the main task is to connect psycholinguistics, sociolinguistics, and identity studies more closely. Such a framework would make it possible to explain how words become part of mental life and social life at the same time. That is the broader significance of linguistic inquiry: language is one of the principal ways human beings think with others and become intelligible to themselves [1-6].

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PHILOSOPHICAL SCIENCES

ONTOLOGY: FROM PHILOSOPHICAL THEORY TO A CONCEPTUALISATION TOOL IN COMPUTER SCINCE

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ОНТОЛОГІЯ: ВІД ФІЛОСОФСЬКОЇ ТЕОРІЇ ДО ІНСТРУМЕНТУ КОНЦЕПТУАЛІЗАЦІЇ У КОМП'ЮТЕРНИХ НАУКАХ

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Abstract
The article analyses the transformation of the concept of ontology from its philosophical origins to its use in computer science and software engineering. The author points out that, in philosophy, ontology is a fundamental theory of being and a condition for the possibility of scientific knowledge. At the same time, in computer science, it becomes a tool for systematising knowledge and building conceptual models of subject domains. Special attention is paid to the distinction between philosophical and computational ontology: the former is aimed at identifying patterns of existence and expanding the horizons of knowledge, while the latter is aimed at the practical application of knowledge through algorithms, databases, and artificial intelligence systems. The author notes that in computer science, ontology serves as a "framework" for organising information, provides shared access to knowledge for users and programs, and also allows for the harmonisation of different fields of knowledge. It is emphasised that philosophical ontology has a worldview value, and computational ontology has an applied one. Thus, the article reveals the dual nature of ontology: as a philosophical theory that underlies scientific knowledge, and as a technical tool that ensures the effective use of knowledge in computer systems.

Анотація
В статті аналізується трансформація поняття онтології від його філософських витоків до використання у комп'ютерних науках і програмної інженерії. Автор вказує, що у філософії онтологія постає як фундаментальна теорія буття та умова можливості наукового пізнання, тоді як у комп'ютерних науках вона стає інструментом систематизації знань та побудови концептуальних моделей предметних областей. Особлива увага приділяється різниці між філософською та обчислювальною онтологією: перша спрямована на виявлення патернів існування та розширення горизонтів пізнання, друга – на практичну реалізацію знань у вигляді алгоритмів, баз даних та систем штучного інтелекту. Автор зазначає, що в комп'ютерних науках онтологія служить «каркасом» для організації інформації, забезпечує спільний доступ користувачів та програм до знань, а також дозволяє узгодити різні галузі знань. При цьому наголошується, що філософська онтологія має світоглядне значення, а обчислювальна - прикладне. Таким чином, стаття розкриває подвійну природу онтології: як філософської теорії, що є підґрунтям наукового пізнання, і як технічного інструмента, що забезпечує ефективне використання знань у комп'ютерних системах.

Keywords: conceptualization, computer science, philosophy, ontology, scientific knowledge
Ключові слова: концептуалізація, комп'ютерні науки, наукове пізнання, онтологія, філософія

Онтологія — поняття, знайоме філософам [Ishchenko Yu., 2002, с. 449], використовується в комп'ютерних науках [Pease A., 2026]. Тут його значення змінилося. У комп'ютерних науках онтологія означає спосіб систематизації знань, що дозволяє виявити неявні зв'язки між даними. «Онтологія в комп'ютерних науках, у широкому сенсі, є способом репрезентації загального розуміння предметної області» [Sanchez D.M., Cavero J.M., Martinez E.M., 2007, с. 3]. Онтологія призначена для каталогізації знань про «дискурсивний всесвіт» [Sharman R., Kishore R., Ramesh R., 2007, с. xi]. Цей каталог побудований так, що його можна легко доповнити або внести зміни. Передбачається, що існує не одна, а множина онтологій [Sharman R., Kishore R., Ramesh R., 2007, с. xii]. Вони створюються шляхом абстрагування, спеціалізації, комбінування баз даних або областей знань, наприклад, хімії, медичної інформатики, бухгалтерського обліку тощо. Вони містять інформацію не тільки про предметну область, але й про способи маніпуляції цією інформацією: шляхи

доступу, зберігання, принципи упорядкування та ін. «Обчислювальна онтологія може забезпечити інформаційні системи структурою для збору та впорядкування інформації» [Huang CH.-R., Chung S.-F., Ahrens K. 2007, p. 490]. Це один з найбільш ефективних способів репрезентації інформації [Huang CH.-R., Chung S.-F., Ahrens K. 2007, p. 491]. Онтологія є концептуалізацією предметної області. У той же час вона має у своєму складі сукупність методів та інструментів, що забезпечують користувачам доступ до баз знань та їх практичне застосування, наприклад, при розробці програмного забезпечення або в процесі його застосування.

Онтології в комп'ютерних науках використовуються в галузях баз даних, програмної інженерії та в процесі програмування штучного інтелекту. На відміну від баз даних, для онтологій є суттєвими зв'язки між даними. Це дає можливість швидко в режимі реального часу обробляти дані, вносити зміни та доповнювати їх, будувати складні судження та висновки, що містять нові знання. Це засіб інтеграції додатків, платформ та знань із різних галузей. Онтологія забезпечує спільний доступ користувачів (людей та програм) до знань завдяки спільній мові, доступному, ясному та однозначному значенню понять, встановленим на основі загальної домовленості. Мета онтології – цілісно описати область реальності, знання про яку закріплені у філософських та наукових поняттях та категоріях [Arp R., Smith B., Spear A.D., 2015, с. 7]. «Онтології є репрезентативними артефактами у тому сенсі, що є загальнодоступними репрезентаціями наукової інформації про реальність» [Arp R., Smith B., Spear A.D., 2015, с. 24].

Мета дослідження: філософський аналіз поняття онтології у комп'ютерних науках.

Показово, як інтерпретується філософська передісторія онтології у працях, присвячених комп'ютерним наукам. Початком онтологічної проблематики вважається класифікація категорій у Арістотеля, далі через Канта до теорії обчислень і, власне, програмної інженерії та математики [Corcho O., Fernandez-Lopez M., Gomez-Perez A., 2006, p. 3]. Онтологія, в такій інтерпретації, — це вчення про те, як обчислити та впорядкувати знання про існуюче. Важливо не лише те, що існує і як воно існує, а й те, як організувати знання таким чином, щоб полегшити їхнє практичне застосування; важливим є інструментальний аспект знання, способи його практичної реалізації. Звідси вимоги доступності та зрозумілості знань, однозначності понять, що використовуються.

На думку авторів монографії «Building Ontologies with Basic Formal Ontology» історія онтологій у програмуванні починається з класифікацій категорій у філософії. Прикладом такої класифікації є Порфірове дерево, яке є графом з вузлами і ребрами. Онтології - це «теоретико-графові структури» [Arp R., Smith B., Spear A.D., 2015, с. 29], тобто ієрархічні відносини між поняттями різного ступеня спільності. Ієрархічні відносини гарантують узгодженість визначень понять та взаємну доповнюваність знань, що надаються різними колективами дослідників та розробників.

Онтології — знання високого ступеня абстракції. Саме ця властивість необхідна для впровадження знань у обчислювальне середовище. Вони створюють спільність розуміння предметної галузі та визначення понять. Забезпечуючи, таким чином, поряд із спільною мовою, доступ до знань всім користувачам – людям та комп'ютерним програмам. Онтології в комп'ютерних науках переймають таку властивість наукових концепцій, як їхня прив'язка до конкретної проблеми, предметної галузі. Вони моделюють певну частину дійсності. Частину, яка може бути співвіднесена з іншими онтологіями та областями реальності завдяки «онтології середовища».

Фахівці у галузі комп'ютерних наук сформулювали своє уявлення про різницю між філософською онтологією та онтологією у комп'ютерній інженерії. Визначення тієї та іншої області знань (у філософії та програмуванні) наведено в роботі «Ontologies A Handbook of Principles, Concepts and Applications in Information Systems».

Якщо філософи-матеріалісти прагнуть описати і подати онтологію як теорію, що відображає об'єктивний (незалежний від свідомості) стан речей та явищ, то вчений-програміст споконвічно заперечує таку можливість у програмній інженерії. Більше того, свідомість становить підґрунтя онтології у комп'ютерних науках. Свідомість укорінена у бутті як його структурний елемент або реальність, що створює навколишній світ.

Автор розділу монографії звертає увагу на складності застосування матеріалістичних та позитивістських онтологій у комп'ютерних науках [Stahl B.C., 2007, с. 119]. Насамперед принципу існування незалежної від спостерігача реальності. Даний тип онтологій марний для вирішення завдань, що виконуються в обчислювальному середовищі. Множинність онтологій передбачає існування багатьох реальностей, які можуть перетинатися [Stahl B.C., 2007, с. 119]. Самі онтології часто містять таксономію. Використовувані в комп'ютерних науках онтології представляють область реальності, складовими якої є спостерігачі (користувачі та розробники).

Проблема в тому, як уявити незалежну від свідомості реальність у обчислювальному середовищі та як вона може бути представлена у свідомості спостерігача. Згідно з твердженнями фахівців комп'ютерних наук, тисячолітня історія філософії не дає однозначної відповіді на це питання. «Філософськи важко підтримувати ідею про те, що світ незалежний від спостерігача» [Stahl B.C., 2007, с. 147]. Доказом неспроможності позитивізму в комп'ютерних науках на думку автора є «…постійно високий рівень відмов інформаційних систем, який зберігається,

незважаючи на десятиліття інтенсивних досліджень» [Stahl B.C., 2007, с. 148].

Альтернативою позитивізму у соціальних та комп'ютерних науках, на думку авторів, може стати феноменологія та поняття «життєвий світ». «З точки зору феноменології позитивізм призводить до багатьох збоїв, представлених системними збоями, незадовільними описами явищ, сліпотою до контексту та соціальних структур і, нарешті, що не менш важливо, нездатністю вирішувати етичні питання інакше, ніж з описової точки зору. Коли такі збої стають очевидними, можливо, варто розглянути, чи не є однією з причин невдачі позитивізму його онтологія. Якщо так, можливо, варто розглянути альтернативи, такі як концепція життєвого світу» [Stahl B.C., 2007, с. 165]. Однак, автор також визнає, що вибір нової онтології не вирішить всіх проблем, можливо, породить нові.

У комп'ютерних науках онтологія – це проєкт концептуалізації реальності. «…онтологія забезпечує базову структуру чи каркас, навколо якого можна побудувати базу знань» [Djurie D., Gasevic D., Devedzic V., 2007, с. 217]. Істинність філософської онтології перевіряється часом, долею та плідністю створеної теорії та кількістю послідовників. Адекватність онтології у комп'ютерних науках визначається ефективністю створених з її допомогою алгоритмів, актуальністю та доступністю бази знань, призначеної для використання людьми та агентами-програмами. Онтологія у програмуванні «захоплює і репрезентує» [Sharman R., Kishore R., Ramesh R., 2007, с. xii]. У цьому її функція – фіксувати та демонструвати інформацію так, щоб вона була однозначною та однаково доступною для всіх користувачів, незалежно від того, чи є вони людьми чи комп'ютерними програмами. Вона прагматична і призначена для користувачів, котрі мають чітко визначену мету чи завдання. Філософська онтологія не може бути однозначно інтерпретована і не містить готові відповіді на запити «користувачів». Вона призначена для активізації свідомості та стимулювання самостійного пошуку. Вона спрямовує свідомість. Філософська онтологія не обмежена дискурсом, хоча може бути формалізована та послідовно викладена. Онтологія в комп'ютерних науках дескриптивна та базується на науковій та філософській теорії. Вона, по суті, відтворює «обмежений всесвіт дискурсу» [Sharman R., Kishore R., Ramesh R., 2007, с. xii]. Вона обмежена також предметною областю, яку відображає, і способом представлення знань про неї. Філософська онтологія є вихідною основою фундаментальної та прикладної науки, зокрема програмної інженерії. Вона є світоглядною і пояснюючою основою будь-якої теорії, відправною точкою наукової теорії. Філософська онтологія має фундаментальне значення для наукового пізнання та розвитку технологій. У комп'ютерних науках онтологія має прикладне значення. У той же час будь-яка онтологія (філософська та обчислювальна) є результатом абстрагування та виявлення патернів реальності.

Філософська онтологія відображає не тільки пізнане, а й те, що знаходиться за його межами. Вона описує світ так, як його розуміє та представляє людина. Вона окреслює межі мислимого. Її створення виходить за рамки будь-яких прагматичних цілей і є реалізацією прагнення пізнавати. Вона життєво потрібна там, де закінчується очевидність. Щоб звільнитися від відчуття перебування в симуляції, потрібен горизонт, що постійно відділяється, перспектива, безперервне переживання вічності.

Філософська онтологія потрібна вченим та філософам для прояснення фундаментальних характеристик дійсності та визначення шляхів пошуку істинних знань. У програмуванні онтологія потрібна всім, як людям, так і застосункам, щоб користуватися загальним доступом до знань. Онтологія тут створює спільність та впорядкованість. Так виникає сфера взаєморозуміння.

Онтологія у програмуванні потрібна і людям, і алгоритмам, як наслідок, її прийняття є вимушеним кроком, тоді як у філософії дослідження онтологічних питань є усвідомленим вільним вибором проблематики досліджень. У програмуванні онтологія надається розробниками та визначається технічними вимогами. У процесі філософських міркувань відповіді на онтологічні питання є результатом пошуку та роздумів філософа.

Онтології у комп'ютерних науках є репрезентацією концептуалізації. У філософії онтологія – це базова абстракція, яка є фундаментом для наукових і філософських міркувань. У програмуванні вона є результатом таких роздумів. Вона є перевіркою того, наскільки життєздатні наукові теорії та чи вистачає людині навичок та вмінь, щоб реалізувати їх у вигляді технічного проєкту. Особливість онтології у вигляді технічної конструкції полягає в тому, що вона не тільки є реалізацією наукових та технічних знань і доступного науковцям рівня абстракцій, а й системою інструментів, методів, що використовуються для її побудови. В неї вбудований «вибір інструментів, які можуть бути використані для знання» [Sanchez D.M., Cavero J.M., Martinez E.M., 2007, с. 8].

Процес розробки онтологій у комп’ютерних науках зворотній до її створення у філософії. Онтологія — це спосіб введення знань про область дослідження в обчислювальне середовище. Оскільки для опису реальності створюється ієрархічна модель, важливо розрізняти суттєві та несуттєві елементи [Sanchez D.M., Cavero J.M., Martinez E.M., 2007, с. 8]. Концептуалізація —- це формування узагальненого уявлення про досліджувану область реальності, що містить її (області) суттєві характеристики. При цьому автори монографії вказують [Sanchez D.M., Cavero J.M., Martinez E.M., 2007, с. 7], що комп’ютерні науки в принципі не ставлять за мету визначати, що є сутність, тобто виокремлювати суттєві характеристики предметної галузі. «Вони

припускають, що все, що може бути представлене, «реально» [Sanchez D.M., Cavero J.M., Martinez E.M., 2007, с. 7] і в цьому сенсі суттєво. Онтологія в комп'ютерних науках не відповідає на питання, що означає бути, існувати. Все, представлене в обчислювальній онтології, є існуючим, реальним і позначається як значуще, важливе в певному відношенні.

У комп'ютерних науках є своя класифікація онтологій. Зокрема, класифікація за рівнем абстрактності (загальності). Онтології верхнього рівня описують характеристики світу, незалежні від предметної галузі чи завдання, заради якої розроблялася конкретна онтологія. Розрізняють онтології конкретних предметних галузей, онтології метаданих та онтології «здорового глузду», «які охоплюють загальні знання про світ, надаючи основні поняття та концепції для таких речей, як час, простір, стан, подія тощо» [Sanchez D.M., Cavero J.M., Martinez E.M., 2007, с. 10].

Питання, чи потрібна глобальна (загальна) онтологія у програмуванні, залишається відкритим. Така онтологія складається з підмножин спеціальних онтологій, що належать до різних додатків та предметних областей, і допомагає гармонізувати відносини між джерелами інформації та даними. Однак, «Створення та підтримка глобальних онтологій є серйозною проблемою» [Sarda N.L., 2007, с. 567]. Це обумовлено тим, що розв'язання поставлених завдань, розробка застосунків і обробка інформації відбуваються незалежно, без узгодження щодо використання мов і впорядкування даних. Тому створення глобальної онтології у програмуванні є не менш складним завданням, ніж у філософії. Автор розділу пропонує створити мережу відносно «незалежних джерел даних на основі їх онтологій. Почати можна з визначення онтологій для існуючих застосунків. Далі можна визначити відповідність між онтологіями, щоб забезпечити зв'язок концепцій та властивостей між джерелами даних. Також можна визначити загальну онтологію, щоб мінімізувати кількість зіставлень між джерелами [Sarda N.L., 2007, с. 568]. Автор вказує на складність, яка полягає в необхідності ручної перевірки інформації в онтологіях, їх узгодження та заповнення новими даними.

Онтологія може бути основою інтеграції різних систем знань чи кількох джерел інформації для оптимізації автоматичної обробки знань. Прикладом може стати автоматизована обробка концептуальних метафор, яка демонструє «як структуровані знання можуть бути оброблені в інформаційній системі» [Huang CH.-R., Chung S.-F., Ahrens K., 2007, с. 489].

Основні галузі комп'ютерних наук, де використовуються онтології – програмна інженерія, створення баз даних та штучний інтелект. Онтології використовуються також в семантичному павутинні. Тут їхнє призначення наближається до того, яке онтологія має у філософії. Вони представляють правила, за якими розшифровується значення даних та їх взаємозв’язки. Суть та відмінність семантичної павутини від сучасного інтернету в тому, що знання стають доступними та зрозумілими не лише для людей, а й комп'ютерних програм.

Застосування онтологій в галузі штучного інтелекту допомагає інтегрувати знання у числення як елемент архітектури або інформаційний ресурс [Ruiz F., 2006, с. 78]. Онтологія є одним із способів представлення знань у обчислювальному середовищі [Sanchez D.M., Cavero J.M., Martinez E.M., 2007, с. 6], необхідних ШІ для прийняття рішень та автономного функціонування. Проте знання не є гомогенними. Вони складаються з окремих систем, концепцій, які можуть бути не узгодженими між собою або суперечити один одному.

Кожне завдання, що стоїть перед розробником, має своє специфічне рішення, відповідно, і спосіб подання знання. Тому ШІ має справу з фрагментарною інформацією, неповними знаннями. Там, де людина використовує фантазію, пам'ять, здоровий глузд, ШІ може спиратися на джерела інформації та алгоритми, доступні йому. Для ШІ світ завжди представлений так, як його знає і розуміє людина, і пізнається лише тими методами, які надала людина.

Великі мовні моделі (різновид ШІ) можуть самі створювати онтології, так звані приховані онтології, які утворюються на основі масивів даних, наданих ШІ у його навчанні. Такі онтології є упорядкованими системами знань, але не мають суворої, чітко закріпленої структури, властивої онтологіям, побудованим людиною.

Онтології в комп'ютерних науках дотримуються логіки дискурсу. Складність їх створення пов'язана зі складністю процесу концептуалізації, упорядкування репрезентації знань, зведення різноманітної інформації в єдину систему, узгодження знань про різні предметні галузі тощо. Великі мовні моделі у процесі створення прихованих онтологій не завжди здатні розрізняти суттєві та не суттєві дані, що призводить до помилок у роботі.

Онтології добре пасують у випадках, коли потрібно надати та зіставити інформацію з альтернативних джерел або ж узгодити конкуруючі концепції. Онтології будуються на основі певної мови і пов'язані з предметною областю, але при цьому вони мають здатність представляти «загальну концептуалізацію» предметної області [Huang CH.-R., Chung S.-F., Ahrens K., 2006, с. 490], що відкриває можливість мати глобальну картину предметної області та системи знань, що її (предметну область) описують. Мова онтології має сукупність обов'язкових характеристик: «Основними вимогами до мови онтологій є чітко визначений синтаксис, формальна семантика, зручність виразів, ефективна система підтримки суджень та достатня потужність» [Alesso H.P., Smith C.F., 2006, с. 109]. Цілісність та впорядкованість знань в обчислювальній онтології забезпечують можливість інтеграції нової інформації та адекватність інтерпретації існуючої. «Також необхідно розуміти, що інформація повинна бути розташована в системі знань, щоб

бути корисною. Один із найбільш ефективних способів розміщення інформації – це помістити її в добре структуровану та повну систему представлення знань, таку, як обчислювальна онтологія» [Huang CH.-R., Chung S.-F., Ahrens K., 2006, с. 491].

Висновки: Поняття онтології значно змінило свій зміст та призначення. Якщо у філософії, це вчення про буття та фундаментальні характеристики реальності, то в комп'ютерних науках воно набуває інструментального характеру і стає способом репрезентації концептуалізації предметної галузі та систематизації знань, що дозволяє виявляти неявні зв'язки між даними, утворити загальну картину предметної області та забезпечує спільне розуміння знань людьми та програмними агентами.

Філософська онтологія постулює об'єктивне пізнання навколишнього світу, залишаючись водночас неоднозначною у своїх висновках, виступає основою для подальшого пізнання. Онтологія в комп'ютерних науках та програмуванні обмежена «всесвітом дискурсу», конкретною предметною областю (доменом). Вона характеризується формалізацією, однозначністю понять і строгістю синтаксису, необхідними для сумісності онтологічних знань з обчисленнями. Адекватність такої онтології перевіряється ефективністю програмного забезпечення та актуальністю баз інформації. Передбачається, що існує не одна правильна онтологія, а множина вузькоспеціалізованих систем знань, здатних змінюватися, еволюціонувати завдяки оновленням і поєднанню з іншими системами знань. Онтології в комп'ютерних науках містять знання про предметну галузь та методи управління цими знаннями, таким чином зникає межа між даними та програмним забезпеченням, створюється єдина інтелектуальна система, яка є основою для розробки ШІ, експертних систем, інтуїтивно зрозумілого та логічно обґрунтованого пошуку та аналізу інформації.

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AGAINST INVARIANCE: REFLEXIVE AGENCY AS A STRUCTURAL LIMIT OF COMPUTATIONAL POLITICAL MODELING

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Abstract

The computational modeling of political processes faces a fundamental epistemological limit rooted in the reflexivity of strategic actors. By adapting to predictive models, these actors systematically erode the invariance of identified regularities — a phenomenon traced through nuclear deterrence strategy and the 2016 U.S. electoral forecasting episode. Recognizing this limitation as structural rather than technical necessitates a shift from predictive invariance toward scenario-based epistemology in political analysis.

Keywords: reflexivity, computational modeling, political epistemology, agent-based modeling, organized complexity, invariance, scenario analysis, security studies.

Introduction

Every computational model of political behavior necessitates a latent presupposition regarding the temporal stability of captured regularities as a fundamental condition for operational utility. While this assumption maintains validity within the natural sciences, where objects of inquiry exhibit ontological passivity relative to their description, political actors represent a fundamentally divergent category. A sovereign state identified as a potential aggressor by a quantitative conflict-prediction framework retains both the strategic imperative and the material capacity to manipulate the signals monitored by that system, such a shift being prompted not by erroneous classification but by the very consequentiality of the model's output [1, pp. 187–190]. This generates a structural antinomy whereby the incremental refinement of a model's accuracy serves to catalyze the exact behavioral adaptations that necessitate its eventual invalidation.

Notwithstanding the accelerated diffusion of agent-based modeling [2], machine-learning architectures [3], and game-theoretic constructs [4] within international relations theory, this paradox has yet to be rigorously synthesized as a unified epistemological constraint. Current critical discourse remains fragmented within disciplinary silos, as the economic sphere addresses the policy-invariance challenge articulated by Robert Lucas [5, pp. 19–22], sociological inquiry utilizes the double hermeneutics of Anthony Giddens [6, pp. 284–286], and financial theory invokes the reflexivity principle of George Soros [7, pp. 27–31]. This study identifies the convergence of these disparate critiques into a singular structural limitation inherent to the computational modeling of political phenomena. By tracing the empirical manifestations of reflexive erosion across two distinct domains, the analysis establishes the necessity of transitioning from a predictive to a scenario-based epistemology, framed as a cognitive posture calibrated to the organized complexity of political systems.

1. Interdisciplinary Convergence as Methodological Strategy

The integration of macroeconomics, sociology, and financial theory into the analysis of computational political modeling constitutes a strictly methodological imperative rather than an eclectic theoretical assemblage. The independent identification of a uniform structural mechanism—specifically, the systemic transformation induced by the participants' absorption of systemic knowledge—across four disciplines operating with divergent ontological objects, conceptual apparatuses, and evidentiary criteria supplies a magnitude of corroboration unattainable within a single disciplinary framework. This logical architecture mirrors empirical triangulation, where the convergence of outputs from autonomous instruments mitigates the probability of correlated error and amplifies measurement reliability without necessitating the refinement of any individual apparatus [8, p. 267].

Robert Lucas established that behavioral parameters within economic frameworks mutate upon the agents' internalization of the designated policy environment [5, pp. 25–26]. Anthony Giddens extended this dynamic across the social sciences, demonstrating that research subjects absorb, contest, and strategically instrumentalize externally generated interpretive constructs, consequently reconstituting the targeted social reality [6, p. 285]. George Soros deployed an analogous mechanism within financial architectures, proving that participant expectations actively construct rather than passively mirror asset valuations, thereby engendering non-equilibrium systemic trajectories [7, pp. 28–30]. Charles Goodhart formalized the operational synthesis, articulating that any statistical regularity elevated to policy salience inevitably destabilizes under the structural strain of its practical application [9, p. 116]. Rather than subjective theoretical variations, these conceptualizations represent independent structural verifications of a singular systemic property, a dynamic acquiring extreme severity within the political domain where the implications of modeling transcend financial parameters to reach existential thresholds.

2. The Compounding Factor: Organized Complexity

Assuming reflexivity constituted the exclusive impediment to predictive validity, the engineering of second-order models anticipating agent adaptation would theoretically neutralize the constraint. Political environments, however, generate a compounding vector of indeterminacy rooted in their structural condition as systems of organized complexity. The analytical taxonomy delineated by Warren Weaver proves essential for categorizing this phenomenon [10, pp. 536–539]. Configurations characterized by organized complexity, defined by the structured and non-decomposable interaction of a moderate quantity of variables, systematically resist both the deterministic methodologies applicable to simple systems and the probabilistic averaging deployed for disorganized complexity. Institutional formations such as alliance networks, deterrence architectures, and constitutional settlements instantiate this intermediate structural topology, featuring an actor density insufficient for the invocation of the law of large numbers alongside a proliferation of causal trajectories precluding closed-form resolution.

The thermodynamic analysis of irreversible processes formulated by Ilya Prigogine clarifies the specific implications of this structural condition for predictive modeling [11, pp. 160–165]. Within systems sustained significantly beyond equilibrium, localized perturbations occurring at structural bifurcation points frequently catalyze qualitative phase transitions, generating post-transition configurations fundamentally undeducible from initial parametric states. Historical discontinuities encompassing the Soviet collapse, the sequential destabilization of the Arab Spring, and the accelerated consolidation of NATO's post-Cold War architecture function as empirical instantiations of political bifurcations characterized by retrospective analytical coherence but prospective predictive opacity. The fragility taxonomy articulated by Nassim Nicholas Taleb supplies the decision-theoretic corollary to this dynamic, establishing that systems exhibiting discontinuous rather than proportional responses to stress vectors generate fat-tailed outcome distributions systematically underweighted by standard forecasting apparatuses [12, pp. 136–139]. The intersection of reflexive agency and organized complexity thereby enforces a dual epistemological constraint, ensuring that computational models face simultaneous internal degradation via strategic adaptation and external invalidation through structural indeterminacy.

3. Empirical Manifestations

The reflexive erosion of predictive invariance functions not as philosophical speculation, but as an empirically recurrent dynamic characterized by identifiable mechanisms and measurable systemic effects. Two specific domains instantiate this phenomenon with high analytical clarity.

Nuclear deterrence. The evolution of nuclear strategy during the Cold War represents an extended episode of reflexive model-invalidation within the political science discipline. Thomas Schelling's formal analysis detailing credible commitment and brinkmanship [4, pp. 119–131] transcended academic isolation, undergoing absorption into Soviet strategic planning. This internalization catalyzed doctrinal adaptations—specifically the engineering of automated retaliation mechanisms ("Dead Hand")—designed strategically to neutralize the precise commitment variables Schelling identified. Each successive iteration of deterrence modeling (mutual assured destruction, flexible response, counterforce targeting) was analytically processed by the adversary, decoded for exploitable theoretical assumptions, and countered with strategic deployments rendering the model's operational parameters obsolete. The eventual consolidation of the arms control regime functioned as structural acknowledgment that competitive behavioral modeling had achieved a reflexive impasse: the mutual effort to secure predictive advantage demonstrably escalated systemic instability rather than mitigating it.

Electoral forecasting. The 2016 United States presidential election provides a temporally proximate and empirically quantifiable illustration. Probabilistic aggregation models assigned the Democratic candidate victory probabilities ranging from 71% to 99%, projections subsequently amplified by mass media apparatuses into a dominant narrative of inevitability [13]. Subsequent peer-reviewed analysis isolated evidence consistent with a structural complacency effect: the public dissemination of high-confidence probabilistic forecasts correlated with diminished voter mobilization among supporters of the projected victor within electorally critical geographies [14, pp. 1536–1540]. The forecasting architecture ceased functioning as a passive observational instrument and mutated into an active variable within the system it evaluated. This mechanism is structurally homologous to Giddens's double hermeneutics, operating not via academic publication but through mass-media amplification at a magnitude that rendered the reflexive feedback loop empirically measurable.

4. Implications for Computational Modeling and Scenario Epistemology

Agent-based modeling (ABM) constitutes the most methodologically self-reflexive response to these structural constraints. By simulating heterogeneous agents operating via individual decision algorithms and localized information access, ABM facilitates the emergence of macro-level systemic patterns from micro-level interactions without enforcing a priori equilibrium assumptions [15, pp. 5–8]. Lars-Erik Cederman's demonstration that recognizable geopolitical architectures—unipolarity, bipolarity, multipolarity—can generate from minimal agent-level behavioral rules exemplifies the generative capacity of ABM frameworks [16, pp. 10–15]. However, ABM does not neutralize the reflexive limit; it merely relocates it. The specific decision rules assigned to simulated entities function as calibrated parameters, subjecting them to the Lucas critique with undiminished intensity: parametric values estimated within one geopolitical regime lack guaranteed validity following a transition to an alternate systemic state.

Three methodological objections require analytical processing. First, the proposition that machine learning architectures detect latent patterns imperceptible to the agents themselves, thereby circumventing reflexive adaptation, maintains validity strictly for short-horizon tactical forecasting where monitored actors lack access to analytical output. This premise collapses at the strategic echelon, where the historical trajectory of nuclear strategy proves that consequential models are systematically internalized and neutralized. Second, adaptive ABM architectures endowing agents with machine-learning capabilities theoretically internalize reflexivity within the simulation space; however, this architecture generates an infinite regress, as empirical actors possess the capacity to adapt not merely to the model itself, but to the modeler's programmed expectation of their adaptation. Third, structural realism posits that material variables—geography, demographic mass, nuclear arsenals—determine systemic outcomes independently of reflexive dynamics [17, pp. 97–101]. This assertion holds partial validity, as material structure defines the spatial boundaries of possibility. Policymakers, however, require trajectory prediction within that delimited space, and it is precisely the directional trajectory that reflexive adaptation renders structurally unstable.

The optimal constructive response, formalized by Joshua Epstein, necessitates a fundamental reconceptualization of computational modeling's primary utility: a transition from prediction to generative sufficiency, aiming to demonstrate that a specified mechanism is capable of producing an observed pattern rather than forecasting which specific pattern will materialize [15, pp. 6–7]. This epistemological reorientation corresponds to an established philosophical distinction: Aristotle's differentiation between episteme—knowledge regarding the necessary and invariant—and phronesis—knowledge concerning the contingent and actionable [18, pp. 1140a–1140b]. Scenario-based computation, integrating Monte Carlo simulations and sensitivity analysis within ABM architectures, generates phronetic knowledge: structured evaluations identifying fragile systemic configurations, determining which interventions alter outcome distributions, and isolating signals indicating proximity to critical thresholds. This constitutes knowledge regarding the topology of systemic possibility rather than the trajectory of specific actuality—representing an epistemology structurally adequate for a domain where the object of analysis operates simultaneously as its most analytical observer.

Conclusion

The central argument of this analysis derives from a singular structural observation: political actors occupy an ontological category fundamentally distinct from the objects of natural-scientific inquiry, an ontological divergence that imposes an absolute constraint upon the epistemic viability of computational modeling. The intersection of reflexive agency, organized complexity, and stochastic contingency generates a tripartite limitation immune to resolution via escalations in computational capacity or methodological sophistication. Empirical data derived from nuclear deterrence strategy and electoral forecasting architectures confirm that this constraint operates as an empirically measurable systemic dynamic, not a theoretical abstraction.

The operational consequence demands epistemological reorientation rather than methodological resignation. Agent-based modeling and scenario analysis maximize their analytical utility precisely upon the abandonment of invariant prediction in favor of mapping the structural parameters of possibility space. Researchers acknowledging the reflexive limit do not terminate the analytical enterprise; they recalibrate its functional objective toward inquiries computationally solvable: determining the structural fragility of specific configurations, measuring outcome sensitivity to targeted interventions, and calculating systemic proximity to critical phase transitions. This framework constitutes the sole epistemology adequate for navigating an environment where the object of knowledge functions simultaneously as its most strategic subject—the fundamental condition of the political domain.

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THE GOALS OF EDUCATION AS THE GOALS OF HUMAN LIFE

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Abstract

The appeal to the problem of identifying the goals of human education is due to the discrepancy between the level of conscious independence of school and university graduates achieved today and the goals of a full-fledged (personal and social) human life. One of the reasons for this discrepancy is, on the one hand, the reduction in hours devoted to studying philosophy in Russian universities. On the other hand, the infocracy which Byung-Chul Han [1] writes about is being introduced into the Russian educational space. The purpose of this article is to identify ways to increase the level of conscious independence of students (schoolchildren and students) in the modern conditions of their lives.

Keywords: life, purpose of life, meaning of life, human education, human soul, human spirit.

The basic concept of this research is *the concept of human life*. Understanding life as a way to resolve the contradiction between the inner and outer worlds of human life serves as the basis for defining the goals of life. By human education, we mean the acquisition of conscious independence in the exploration of space and time of human life. And this development occurs as a result of human activity, the object of which is a person himself. Education should contribute not only to the achievement of human life goals, but also to the realization of their significance and meaning. By meaning, we understand the importance of human performance for the future.

The traditional goals of man's personal and private life are well known: at a young age, he needs to get an education, master a profession, create a family and normal living conditions. But the goals of a person's social life, which are historically specific to each state, are largely uncertain.

The common grounds for determining the goals of man's personal and social life are his natural qualities: dependence on the inner and outer worlds of life, uncertainty of attitude to the outer and inner worlds, rhythmic processes of life, procreation, the ability to transform the energy of the outer world into the energy of the inner world and vice versa. The need to realize these qualities serves as the basis for determining the goals of life. Thus, the feeling of dependence generates a desire to reduce it, and the result of the realization of this desire is the freedom a person finds. Reducing the degree of uncertainty is achieved through a person's knowledge of himself and the outside world, including knowledge of the rhythms of life. Physical and intellectual labor, and human creativity have become a way to transform the energy of the outside world into the energy of the inner world. Mental and spiritual qualities of a person that determine his emotional life refer to the properties acquired in the course of human history.

The presence of positive (ability to work, emotional and intellectual) and negative (dependence and uncertainty) qualities of a person indicates the inconsistency of his development, the resolution of which is entrusted to human education, the purpose of which is to increase the level of his conscious independence. Achieving this goal allows a person to be independent in his life, to determine the further goals of his life by himself. Thus, the goals of a person's education at the beginning of his life are the goals of his life. But the possibilities of achieving further life goals depend on the external world of a person's life, which is always historically specific.

What we have said does not contradict Michel Montaigne's definition of the purpose of life: "The goal, as I believe, is always the same for everyone, namely, to live freely and independently; but people do not always choose the right path to it" [2, p. 373].

The question of choosing the path to freedom and independence is determined primarily by the relationship between the inner world of a person's life and the outside world. The external world, which includes the forces of nature and society, is opposed by the forces of the inner world of human life. Understanding the patterns of interaction between these worlds is the basis for choosing paths to human freedom and independence.

Mythology, religion, philosophy, and science have played a leading role in determining the paths to freedom and independence in the history of mankind. Art has contributed and continues to contribute to this process, shaping the human soul and expressing the ideals of human spiritual life. (By spirit, we mean a person's desire to achieve the ideals of life, and the soul owes its birth to the harmonious integrity of feelings.)

In this regard, let us mention only one of the "Seven Wonders of the World" – the Colossus of Rhodes, erected in 294-282 BC on the Greek island of Rhodes, expressing the greatness of the spirit of the defenders of the island from the invaders in 305-304 BC. Art can also express the uncertainty of a person's perception of the world. Thus, at the beginning of the 20th century, abstract artists (M. Chagall, K. Malevich, V. Kandinsky, and others) expressed in their works the uncertainty of human life, a characteristic feature of modern life and education in the 21st century, due to the phenomenon of infocracy.

The choice of a person's life path was influenced not only by mythology or religion itself, but by their interaction with various forms of social consciousness, for example, religion and art, mythology and philosophy, philosophy and science. It is no coincidence that Jean-Jacques Rousseau wondered about the influence of the renaissance of sciences and arts on the improvement of morals [3]. Today, Artificial Intelligence (AI) is the leader in influencing the way people are educated. The negative result of its influence is the loss of opportunities to increase the level of conscious independence of students and self-deception in assessing their achievements. Thanks to the action of AI, the external world of a person is individualized, and the social world is alienated. As a result, a person does not take part in resolving the contradictions between the public and private lives of his contemporaries.

At the beginning of the 20th century, the famous Russian writer Leo Tolstoy called for detachment from the problems of public life. In his "Address to the Russian People, to the government, Revolutionaries and the People" in 1906, he advised the following:

"In order for people to become better, it is necessary that they pay more and more attention to themselves, to their inner lives. External social activity, especially social struggle, always distracts people's attention from inner life and therefore, always inevitably corrupting people, lowers the level of public morality, as it happened everywhere and as we see it to an amazing extent now in Russia" [4, p. 390].

L. Tolstoy assessed participation in bourgeois revolutions associated with the death of people as an immoral act. He saw the improvement of the external world of people's lives in improving the work of individuals. The insufficiency of this method of improving public life seems obvious, and the history of European states, as well as Russia, speaks of disagreement with Tolstoy's understanding of public morality. The great writer underestimated the unity of the inner and outer worlds of human life, which was recognized in the books of the Old and New Testaments. The human soul painfully perceives a violation of the harmony of what is due (possible) and what is true (real) in people's lives.

The Russian writer, public figure and statesman of the end of the XVIII century A.N. Radishchev at the beginning of the story "Journey from St. Petersburg to Moscow" speaks about a change in the state of the soul, influenced by the outside world: "I looked around me, and my soul was wounded by the sufferings of humanity" [5, p. 41]. Let's just note that people's souls vary. Therefore, the education of the soul is not an easy task, but an very important one of human education, which has not yet found proper appreciation.

Reducing the hours devoted to studying philosophy at Russian universities does not contribute to understanding the peculiarities of modern human thinking, which is characterized by students' absolute trust in information coming from various sources. Francis Bacon's teaching about idols, "which besiege people's minds" [6, p. 18], is relevant today. We have to admit that in addition to the idols of the clan, cave, square and theater, a new kind of idol has appeared – infocracy, which manifests itself in various areas of human life.

What should a person do to make his education contribute to the improvement of his life? Answering a similar question, Leo Tolstoy writes:

"The first thing is not to lie to yourself.…

The second is to renounce the consciousness of being right, of one's advantages, of one's peculiarities in front of other people and admit oneself guilty.

The third is to fulfill that eternal, indubitable law of man – by the labor of his whole being, without being ashamed of any labor, to fight against nature in order to maintain his own and other people's lives" [4, p. 351].

To what has been said, we add the following: both in human education and in his work, one should focus on the realization of the historical trend of increasing the degree of his conscious independence. This tendency manifests itself both in ontogenesis and in the phylogenesis of human life.

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TECHNICAL SCIENCES

ARCHITECTURE OF ADAPTIVE WEB PLATFORMS FOR MATERIAL MANAGEMENT IN MANUFACTURING COMPANIES: SCALABILITY, MODULARITY, AND INTEGRATION

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Abstract

The article examines engineering approaches to the design of adaptive distributed web platforms for material management in manufacturing companies within the context of industrial digital transformation. The limitations of monolithic architectures are analyzed, and the rationale for transitioning to service-oriented models based on API Gateway, Backend-for-Frontend, and event-driven backend patterns is substantiated. Quantitative load-testing results and practical examples of integration with corporate ERP systems are presented. Particular attention is given to scalability, fault tolerance, master data governance, and consistency maintenance in distributed environments. It is demonstrated that the adoption of hybrid integration models and centralized validation mechanisms establishes the foundation for a resilient enterprise digital ecosystem and enhances transparency in material and logistics processes.

Keywords: distributed architecture, web platforms, material management, API Gateway, Backend-for-Frontend, event-driven architecture, ERP integration.

Introduction

In the context of industrial digital transformation, material flow management has become strategically important for ensuring production stability, cost efficiency, and supply chain transparency. Modern manufacturers operate within complex supply networks, distributed warehouse infrastructures, and evolving integration environments, while traditional monolithic systems often lack the flexibility required for scalable and near real-time operations. These conditions necessitate a reconsideration of architectural approaches to web-based material management platforms.

Distributed web systems supported by patterns such as API Gateway, Backend-for-Frontend (BFF), and event-driven backends enable modular, scalable, and resilient platform design. In industrial settings, such architectures must ensure accurate high-value material accounting, batch traceability, synchronized planning, and high service availability (99.9% or higher), making architectural decisions both technical and managerial instruments for maintaining operational reliability.

The research is intended to analyze engineering approaches to the design of adaptive distributed web platforms for material management in manufacturing companies, with a focus on scalability, modularity, and integration with ERP systems. The research applies methods of comparative architectural analysis and generalization of industrial development practices. The study aims to identify the advantages of implementing API Gateway, BFF, and event-driven backend patterns in large industrial enterprises and to formulate substantiated recommendations for building evolutionarily sustainable digital platforms.

Main part. Engineering foundations of distributed web platforms for material management

Modern manufacturing companies operate in conditions characterized by high dynamics of material flows, geographically distributed warehouse infrastructures, and complex cooperative relationships with suppliers. According to the MHI Annual Industry Report 2025, 75% of companies consider supply chain synchronization to be a challenging task, while 80% of respondents report significant difficulties in forecasting material flows (fig. 1).

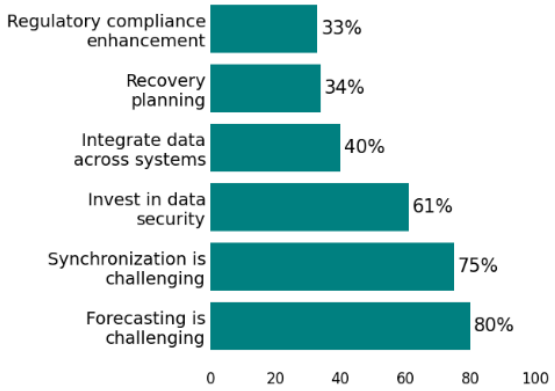

Figure 1. Key supply chain synchronization and forecasting challenges according to the MHI Annual Industry Report 2025, % of respondents [1]

The obtained data indicate that a key constraint on the sustainable functioning of distributed manufacturing systems remains the insufficient coordination of information flows and the fragmentation of digital infrastructure. Under these conditions, the architecture of web-based material management platforms must ensure not only the processing of substantial volumes of transactional data, but also end-to-end integration of distributed information sources, near real-time synchronization of inventory status, and scalability in response to increasing workloads and a growing number of interacting counterparties [2].

These requirements necessitate a reassessment of traditional enterprise architectures. The traditional monolithic systems, developed according to a centralized IT model, are characterized by a high level of component coupling and low flexibility, while a distributed web platform architecture is based on a service-oriented decomposition model, providing flexibility and digital resilience (table 1).

Table 1

Comparison of monolithic and distributed architectures for material management web platforms

Criterion	Traditional monolithic architecture	Distributed web-platform architecture
Structural organization	Single codebase and unified runtime process; tightly coupled business logic, UI, and integration layers.	Service-oriented decomposition by functional domains; independent services, BFF layer, API Gateway.
Scalability model	Primarily vertical scaling; entire application scales as a single unit, including non-loaded modules.	Horizontal scaling; only high-load services are replicated; container- and node-level autoscaling.
System integration	Point-to-point integrations; rigid dependencies; complex modification of integration flows.	REST/gRPC APIs, message brokers, event-driven communication; standardized interaction contracts.
Data and transaction processing	Centralized database; tightly coupled transactional logic; higher risk of locking under load.	Polyglot persistence; bounded contexts; asynchronous workflows; eventual consistency and outbox/inbox patterns.
Fault tolerance	Failure of a critical module may impact the entire system; limited fault isolation.	Service-level isolation; retry mechanisms, circuit breakers, graceful degradation, independent recovery.
Deployment and release management	Full system rebuild and redeployment required; increased regression risk.	Independent service deployment; CI/CD pipelines; containerization; rolling and canary updates.
Observability and operations	Limited monitoring granularity; difficult bottleneck localization.	Distributed tracing, centralized logging, service-level metrics, SLA/SLO monitoring.

The comparative analysis indicates that the shift from monolithic systems to distributed web-platform architectures is driven by the need to ensure controllability of complex material and logistics processes. Such platforms use domain-based decomposition, API contracts, event-driven interaction, and service-level observability to support fault isolation, scalable load management, and data consistency within distributed systems. In effect, architecture is no longer just a technological construct but a structural enabler for production resiliency and adaptability to changing conditions within an organization.

Architectural patterns as a mechanism for ensuring scalability and controllability of distributed web platforms for material management

The development of distributed web platforms for material management necessitates the use of specialized architectural patterns that ensure the controllability of complex service ecosystems, flexibility in functional evolution, and resilience to increasing workloads. Within an industrial enterprise, the system must simultaneously serve internal units (procurement, warehousing, production planning departments), external suppliers, and ERP integration environments, thereby imposing stringent requirements on access unification, security enforcement, and interaction control.

In this context, the **API Gateway pattern** represents an engineeringly justified solution that enables centralized request routing, authentication, authorization, and interface version control. A single entry point simplifies the management of security policies (OAuth 2.0, JWT), rate limiting, and traffic monitoring. As the number of microservices increases – often reaching dozens or more – this approach significantly reduces the coupling between client applications and the internal backend structure, thereby enhancing architectural resilience to change.

The engineering robustness of the API Gateway approach is supported by contemporary load-testing results. For example, in benchmark testing of **Kong Gateway 3.6.x conducted in a Kubernetes** environment on AWS, each scenario was executed five times for 15 minutes over HTTPS and included a baseline proxy configuration, rate limiting without authentication, as well as combinations of rate limiting with Key Auth and Basic Auth mechanisms. The results demonstrate that even when scaling the configuration to 100 routes and 100 consumers, the gateway maintains high throughput – ranging from 125,803.9 RPS in the baseline mode to 92,707.1 RPS when Key Auth and rate limiting are enabled simultaneously – while P99 latency increases only moderately, from 6.11 ms to 9.46 ms (table 2).

Table 2

Performance testing results of Kong Gateway 3.6.x [3]

Scenario	Configuration	Throughput (RPS)	P99 Latency (ms)
Proxy mode, no plugins	1 route, 0 consumers	130,014.2	6.01
Proxy mode, no plugins	100 routes, 0 consumers	125,803.9	6.11
Rate limiting (no authentication)	100 routes, 0 consumers	108,435.5	7.85
Rate limiting + Key Auth	1 route, 1 consumer	97,163.6	9.30
Rate limiting + Key Auth	100 routes, 100 consumers	92,707.1	9.46

These results indicate that centralized implementation of security and traffic management functions can be achieved without substantial performance degradation, even as the service topology becomes more complex. Consequently, the API Gateway pattern may be considered not only a governance mechanism, but also a technically scalable component capable of supporting the growth of distributed microservice ecosystems under industrial workloads.

In environments with heterogeneous user scenarios, the **BFF pattern** is particularly suitable. In manufacturing systems, different user groups – such as warehouse operators, procurement specialists, and project managers – require varying data structures and levels of aggregation [4]. A dedicated backend layer per interface optimizes data exchange, reduces redundant service calls, and maintains response times within 200–300 ms under high load. Additionally, BFF limits cascading changes in microservice architectures when user interfaces are frequently updated.

Quantitative evidence from modern enterprise API aggregation platforms confirms the engineering validity of applying the BFF pattern. In recent **AWS architectural material**s, this pattern is described as a mechanism for reducing excessive frontend "chattiness" and enabling the delivery of aggregated data through a dedicated backend layer. Furthermore, according to **Apollo GraphOS**, the implementation of batching and entity caching in production environments has been associated with reductions in median response time and an 8–10-fold decrease in traffic to underlying services, thereby demonstrating the effectiveness of a frontend-oriented backend layer in distributed service architectures [5].

A substantial role in ensuring the scalability and responsiveness of the platform is played by an **event-driven backend architecture**. In material management systems, a significant proportion of business processes are inherently event-based, including the receipt of material batches, changes in procurement status, detection of shortages, and adjustments to production schedules. Asynchronous processing of such events through message brokers enables the offloading of synchronous API interactions and enhances resilience under peak load conditions.

Quantitative results from contemporary benchmark testing confirm the engineering robustness of this approach. For example, in official performance testing of **Apache Kafka** conducted on a three-node cluster with 100 partitions and a replication factor of three, a peak stable throughput of 605 MB/s was achieved (table 3).

Table 3

Performance characteristics of Apache Kafka in event-driven processing scenarios [6]

Parameter	Configuration	Value
Peak stable throughput	3-node cluster, 100 partitions, replication factor = 3	605 MB/s
Sustained message rate (latency testing)	1 KB messages	200,000 messages/s
Partitions (scaling scenario)	Large-scale configuration	up to 100,000 partitions
End-to-end latency (P99)	High-load streaming scenarios	tens of milliseconds*

**Depending on workload characteristics and cluster configuration.*

The combination of API Gateway, BFF, and an event-driven model forms the architectural framework of an adaptive web platform that ensures centralized access and security management, optimization of user-specific interaction scenarios, and asynchronous processing of business events. Such a configuration supports stable operation amid increasing integration complexity and operational load, while maintaining a balance between performance, controllability, and flexibility. At the same time, the event-driven layer and chains of independent event handlers provide a technological foundation for implementing intelligent mechanisms for automated monitoring and supply audit processes, which aligns with research in intelligent automation of B2B SaaS platforms demonstrating improved deviation detection speed and reduced reliance on manual control [7].

Integration of an adaptive material management web platform with corporate ERP systems

In most large manufacturing companies, the ERP system (SAP ERP/S4HANA, Oracle ERP, 1C ERP, etc.) functions as a centralized repository of master data, financial information, and regulatory reporting. The material management web platform, in turn, provides a more flexible and operationally responsive environment for managing inventory, procurement, and supplier interactions. Therefore, the objective of

integration is not to duplicate ERP functionality, but to establish a coordinated architectural distribution of responsibilities between systems while ensuring data integrity and consistency [8]. From an engineering perspective, various integration models are employed (table 4).

Table 4

Integration models between the material management web platform and ERP systems

Integration model / technical implementation	Interaction characteristics	Advantages	Limitations and typical use cases
Synchronous API integration / REST / SOAP services	Real-time request–response	Immediate confirmation of operations; clear transactional control.	Sensitive to latency and temporary failures; suitable for critical operations (budget reservation, limit validation).
Enterprise Service Bus (ESB) integration / Centralized message routing and transformation layer	Mediated system-to-system communication	Unified integration governance; protocol transformation; centralized monitoring.	Potential bottleneck; increased complexity under high load
Change Data Capture (CDC) / Database log-based replication; streaming change events	Data-level synchronization	Minimal impact on business logic; efficient master-data propagation.	Possible propagation delays; requires consistency control mechanisms.
Asynchronous event-based integration / Publication and subscription of business events between systems	Decoupled, non-blocking interaction	Resilience to failures; reduced ERP load; scalable data flow.	Eventual consistency; requires idempotency and monitoring of delivery guarantees.

Practical experience of U.S. manufacturing companies confirms the effectiveness of hybrid integration architectures in material management systems. For example, **Glidewell** (USA) implemented Microsoft Dynamics 365 Finance and Dynamics 365 Supply Chain Management to integrate inventory control, procurement, and financial operations within a unified ERP environment. Following the phased integration of distributed operational processes, the company reported a 12% increase in order processing capacity, a 40% reduction in order fulfillment costs, and a 28% acceleration in purchase order processing without expanding procurement staff [9]. This case demonstrates that the integration of adaptive web-based material management platforms with ERP systems yields measurable performance improvements when responsibilities are clearly distributed between operational and financial layers and when data consistency and process standardization are ensured across the enterprise digital architecture.

However, the effectiveness of such integration architectures is critically dependent on the quality and consistency of shared data across systems. Even the most advanced integration model cannot ensure operational stability if discrepancies persist in master records exchanged between the web platform and the ERP environment. In this context, particular attention must be paid to **master data management (MDM) and to maintaining consistency across material, supplier, and warehouse reference directories.**

For example, when the material master data volume reaches several hundred thousand items, even minor inconsistencies in coding structures or material attributes may lead to planning errors and procurement disruptions. At the same time, ensuring a specific response time when working with large reference data sets requires optimization of data access mechanisms, including caching and query optimization, as is also indicated by relevant research on web application performance.

It is advisable to implement **centralized mechanisms for validating and versioning master data**, including schema validation, reference data integrity, attribute normalization, and version control of master data, when working within a distributed system architecture. To ensure that duplicate transactions are not executed and to ensure reliable data exchange, it is advisable to implement idempotent message processing strategies, including the use of unique event ids, deduplication, transactional outbox, and delivery patterns.

As a practical example, the U.S.-based manufacturing company **Taylor Farms**, operating more than 22 production facilities across North America and employing over 24,000 staff, can be considered. As part of its digital transformation initiative, the company implemented an integrated architecture based on Dynamics 365 Supply Chain Management and Dynamics 365 Finance, enabling process standardization and unified data access across its enterprise network [10]. A critical step was the transition to a single consolidated item master instead of fragmented regional reference directories, which improved planning data consistency, enhanced traceability, and simplified cross-system integration. In addition, the company utilizes Inventory Visibility, integrates with external warehouse management systems (WMS), and implements centralized reporting through a data lake and Power BI. This case demonstrates the practical importance of centralized validation, harmonization, and governance mechanisms for master data within a distributed material management architecture.

These integration requirements become especially stringent in industries with high traceability and compliance demands, including aerospace manufacturing. In the **aerospace industry**, the integration of a material management web platform with ERP and adjacent systems (PLM, MES) becomes particularly complex. Production cycles may extend over 5–15 years, while the cost of individual items (such as composite panels or titanium billets) can be substantial, requiring strict traceability down to the batch, certification, and supplier levels. Any data desynchronization between the operational material management system and the ERP environment may result in assembly delays, disruption of production schedules, and financial losses. Furthermore, engineering change management processes require timely updates of material specifications across all integrated systems. Therefore, the integration architecture must ensure transactional integrity for critical operations, audit transparency, and compliance with industry quality standards (e.g., AS9100, ISO 9001).

Thus, the integration of a distributed web platform with ERP systems constitutes a complex engineering challenge requiring a careful balance between data processing speed, fault tolerance, and stringent accounting accuracy requirements. The adoption of hybrid integration models, centralized master data governance, and event-driven exchange mechanisms provides the foundation for establishing a unified enterprise digital environment capable of supporting scalability and the functional evolution of the material management system. Furthermore, the development of integration architectures is increasingly viewed in the context of implementing intelligent coordination and automation mechanisms for cross-system processes. Contemporary models integrating multi-agent systems and no-code architectures demonstrate the feasibility of building adaptive enterprise control environments in which interactions between ERP systems, web platforms, and adjacent systems are orchestrated through intelligent rules and automated workflows.

Conclusion

The analysis of engineering approaches to designing adaptive material management web platforms demonstrates that the transition from monolithic systems to distributed architectures represents a natural stage in the digital transformation of industrial enterprises. Increasing supply chain complexity and the need for scalable, resilient information systems require service decomposition, containerization, and horizontal scaling to prevent stable platform performance and high availability under intensive workloads. The application of architectural patterns such as API Gateway, BFF, and event-driven backend provides the technological foundation for modular evolution, reduced component coupling, and improved performance under peak loads. At the same time, integration with ERP, PLM, and MES systems demands robust master data governance and transactional integrity, particularly in industries with strict traceability requirements. Consequently, the development of adaptive distributed material management platforms should be regarded as a strategic direction in enterprise IT architecture, ensuring resilience, transparency, and long-term digital readiness.

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VETERINARY SCIENCES

MORPHOLOGICAL BLOOD PARAMETERS OF TURKEYS DURING ACUTE AND CHRONIC HISTOMONOSIS

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Abstract

The study aimed to evaluate morphological blood parameters in turkeys with acute (50-day-old) and chronic (120-day-old) histomonosis (n=16). In the acute course, a decrease in hemoglobin (–2.6%) and erythrocytes (–3.0%) was observed, accompanied by pronounced leukocytosis (+24.5%). The leukogram revealed an increase in eosinophils (+23.8%) and band neutrophils (+105.3%), indicating a left shift. The leukocyte intoxication index (LII) increased to 0.93 (+52.5%). In the chronic course, more pronounced anemia was detected, with hemoglobin decreasing by 15.8% and erythrocytes by 7.6%. Leukocytosis was less marked (+13.0%), but eosinophilia (+50%) and a decrease in segmented neutrophils (–9.7%) were recorded. LII reached 0.79 (+25.4%). The results indicate that morphological blood parameters are informative markers for assessing the severity and stage of histomonosis in turkeys.

Keywords: turkeys, histomonosis, hematology, leukogram, leukocyte intoxication index

Introduction

Protozoan invasions in poultry cause lesions of the intestine and liver and are accompanied by pronounced changes in hematological parameters [1, 2]. Under modern intensive poultry farming conditions, these diseases remain one of the leading causes of decreased productivity and reduced flock survival [3].

Turkey poults in early ontogenesis are exposed to numerous stress factors, including inadequate nutrition, improper housing conditions, bacterial infections, as well as helminth and protozoan invasions. These factors lead to reduced natural resistance of the organism and suppression of the hematopoietic function of the bone marrow [4]. Stress is known to be one of the key factors negatively affecting the immunobiological reactivity of animals and poultry [5], while parasitic invasions caused by helminths and protozoa act as immunosuppressive agents, contributing to the development of immunodeficiency states and increasing susceptibility to infectious diseases [6].

The immune system is considered an integrated complex of cellular and humoral components, including lymphocytes, plasma cells, and macrophages, which provide complex protective reactions of the organism. Its functioning is mediated through specific immune mechanisms involving antibodies and sensitized cells, as well as through nonspecific mechanisms implemented by various cellular and physiological systems [7, 8].

In the intestinal mucosa, *Eimeria* spp. and *Histomonas meleagridis* release metabolites that exert toxic effects on turkey tissues and suppress both cellular and humoral components of the immune system. In mixed invasions, disturbances of both specific and nonspecific immune responses are observed, contributing to the generalization of the pathological process [9]. Chronic parasitic diseases, in turn, lead to profound disorders of the hematopoietic, antioxidant, and immune systems, which are associated with the toxic effects of parasite metabolites and metabolic alterations [10].

Reduced functional activity of the immune system in poultry leads to increased susceptibility to diseases, decreased viability, and lower productivity. In this context, blood investigation becomes particularly important as one of the most informative biological substrates [11].

Blood is a key component of the internal environment of the organism, ensuring the maintenance of homeostasis, while at the same time being highly dynamic and sensitive to physiological and pathological changes [12, 13]. Its clinical and diagnostic significance is обусловated by its continuous interaction with organs and tissues, which enables the reflection of internal physiological and

pathological processes through qualitative and quantitative changes in hematological parameters [14, 15].

According to the literature, histomonosis in turkeys is associated with significant biochemical and hematological disorders, including decreased albumin levels and increased globulin concentrations [16].

Similar hematological alterations have also been described in mixed protozoan invasions. In partridges infected with *Histomonas* spp. and *Tetratrichomonas*, pronounced leukocytosis accompanied by increased numbers of neutrophils, lymphocytes, monocytes, eosinophils, and basophils was observed, indicating an intensive inflammatory and parasitic response of the organism. Hemogram analysis revealed a significant increase in leukocyte counts (by 165.8%; 49.87 ± 7.82), neutrophils (by 617.9%; 9.62 ± 3.41), lymphocytes (by 156.4%), as well as monocytes and eosinophils ($P < 0.05$). At the same time, a decrease in hemoglobin levels (–26.9%) and erythrocyte counts (–19.2%) was recorded compared to clinically healthy birds. Basophil levels also tended to moderately increase (+16.0%) [17].

It is well known that eosinophilia is a characteristic feature of parasitic invasions and allergic reactions [18, 19]. In poultry affected by histomonosis, increased numbers of monocytes/macrophages and decreased heterophils in peripheral blood have also been reported, which is explained by their migration to inflammatory lesions [20].

The immune response plays an important role in the pathogenesis of histomonosis. It has been demonstrated that an effective local immune response in the intestine can limit parasite dissemination, whereas insufficient immune protection contributes to the generalization of the pathological process. In turkeys, an increased number of lymphocytes, particularly cytotoxic T cells, has been observed in the ceca, indicating the involvement of immunopathological mechanisms in disease development [21].

Clinical and laboratory studies indicate that anemia, leukocytosis, leukocyte formula shift, and alterations in liver enzymes (AST, LDH) may serve as indicators of severe histomonosis and associated complications [22]. At the same time, the course of infection largely depends on the bird species; in turkeys, histomonosis is characterized by a more severe course compared to chickens, which is associated with differences in immune responses [23].

It has been established that cellular immunity plays a leading role in protection against *Histomonas meleagridis*, whereas the humoral response is considered less significant. Moreover, turkeys develop a less effective early local immune response in the intestine, which contributes to the development of severe forms of the disease [24].

The relevance of morphological blood studies is determined by their high informative value for assessing the functional state of the poultry organism, early diagnosis of pathological processes, and evaluation of the severity of parasitic diseases, particularly histomonosis.

The aim of the study was to determine the characteristics of morphological blood parameters in turkeys with acute and chronic histomonosis.

Materials and methods

The study was conducted at the Laboratory of Epizootology, Animal Disease Monitoring and Providing of the Odessa Research Station of the National Scientific Center "Institute of Experimental and Clinical Veterinary Medicine" (NSC "IECVM"). The experimental group consisted of 16 turkeys, including 8 birds aged 50 days with acute histomonosis and 8 birds aged 120 days with chronic histomonosis. Clinical signs of the acute (intestinal) form included diarrhea and depression, whereas the chronic (hepatic) form was characterized by anemia, emaciation, feed refusal, and cyanosis in the head region. The diagnosis was finally confirmed by pathological and anatomical examination.

For morphological studies, blood samples (2–3 mL) were collected from turkeys after slaughter using sterile syringes and subsequently used for hematological analysis.

Morphological blood parameters were determined using conventional hematological methods (Kondrakhin et al., 1985). Erythrocyte counts and hemoglobin concentration were measured photometrically using a FEC-M photocolorimeter according to the method of Havrylets (1966), while leukocyte counts were determined using a Goryaev counting chamber (Chumachenko, 1991). The leukogram was evaluated by differential counting of leukocyte types in fixed blood smears stained according to Romanowsky–Giemsa. In addition, hemoglobin concentration was assessed using the hemoglobin cyanide method (Derviz & Vorobyov, 1959).

Blood smears were also examined to determine the proportion of erythrocytes with signs of toxic granulation, and the leukocyte intoxication index (LII) was calculated according to the method of Starykov and Kushch (1985) using formula (1).

Leukocyte Intoxication Index (LII):

$$LII = \frac{(4\times My+3\times Ju+2\times Ba+Se)\times(Pl+1)}{(Mo+Ly)\times(Eo+1)} \quad (1)$$

My – myelocytes;
Ju – juvenile neutrophils;
Ba – band neutrophils;
Se – segmented neutrophils;
Pl – plasma cells;
Mo – monocytes;
Ly – lymphocytes;
Eo – eosinophils.

The animal experiments conducted in this study complied with the current legislation of Ukraine (Article 26 of the Law of Ukraine No. 5456-VI of 16 October 2012 "On Protection of Animals from Cruel Treatment"), the "General Ethical Principles for Animal Experiments" adopted by the First National Congress on Bioethics (Kyiv, 2001), and international bioethical standards, including the provisions of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1985) [25, 26].

Research results. In 50-day-old turkeys with acute histomonosis, a significant decrease ($p < 0.001$)

in hemoglobin concentration by 2.6% (98.5 ± 0.5 g/L) was observed compared to clinically healthy birds (101.1 ± 0.3 g/L), due to a 3.0% reduction in erythrocyte count (Table 1).

Table 1.

Morphological blood parameters of 50-day-old turkeys with acute histomonosis (n = 8, M ± m)

Parameters	Experimental group	Control group	% of control
Hemoglobin, g/L	101.1 ± 0.3	98.5 ± 0.5***	–2.6
Erythrocytes, T/L	30.1 ± 0.1	29.2 ± 0.2***	–3.0
Leukocytes, G/L	30.6 ± 0.1	38.1 ± 0.1***	+24.5
Leukogram, %			
Basophils	0.5 ± 0.1	–	–
Eosinophils	2.1 ± 0.2	2.6 ± 0.8*	+23.8
Juvenile neutrophils	0.5 ± 0.1	0.3 ± 0.1*	–40.0
Band neutrophils	1.9 ± 0.2	3.9 ± 1.0*	+105.3
Segmented neutrophils	34.1 ± 1.9	32.6 ± 1.2*	–4.4
Lymphocyte	56.3 ± 2.9	57.2 ± 0.9***	+1.6
Monocyte	4.6 ± 0.2	3.4 ± 0.1*	–26.1
Leukocyte intoxication index	0.61	0.93	+52.5

Note: *p < 0.05, **p < 0.01, **p < 0.001 compared with the control group

In the experimental group of turkeys, a significant increase (p < 0.001) in leukocyte count by 24.5% (38.1 ± 0.1 G/L) was recorded compared to 30.6 ± 0.1 G/L in the control group. The leukogram revealed a significant increase (p < 0.05) in eosinophil count by 23.8% (2.6 ± 0.8%) compared to 2.1 ± 0.2% in clinically healthy turkeys. The number of band neutrophils in infected turkeys significantly increased (p < 0.05) by 105.3% and reached 3.9 ± 1.0% versus 1.9 ± 0.2% in the control group. These findings indicate a severe course of the intestinal form of histomonosis. The left shift of leukocytes suggests destruction of intestinal tissue, allowing the parasite to penetrate blood vessels and reach the liver through the portal vein, thereby contributing to the transition of the disease into a chronic form. A significant decrease (p < 0.05) in monocyte count by 26.1% (3.4 ± 0.1%) compared to 4.6 ± 0.2% in the control group was also recorded, indicating immunosuppression and the development of aplastic anemia.

In clinically healthy turkeys, the leukocyte intoxication index (LII) was 0.61 conventional units, whereas in infected birds it reached 0.93 conventional units, which was 52.5% higher. An increase in LII indicates progression of the disease toward a chronic stage.

Investigation of morphological blood parameters in turkeys with chronic histomonosis revealed a significant decrease (p < 0.001) in hemoglobin concentration by 15.8%, reaching 96.8 ± 0.9 g/L compared to 115.0 ± 0.5 g/L in clinically healthy birds (Table 2).

Table 2.

Morphological blood parameters of 120-day-old turkeys with chronic histomonosis (n = 8, M ± m)

Parameters	Control group	Experimental group	% of control
Hemoglobin, g/L	115.0 ± 0.5	96.8 ± 0.9***	–15.8
Erythrocytes, T/L	29.1 ± 0.1	26.9 ± 0.2***	–7.6
Leukocytes, G/L	32.3 ± 0.3	36.5 ± 0.5***	+13.0
Leukogram, %			
Basophils	0.5 ± 0.1	0.3 ± 0.1*	–40.0
Eosinophils	1.6 ± 0.1	2.4 ± 0.2**	+50.0
Juvenile neutrophils	0.5 ± 0.1	0.5 ± 0.1	–
Band neutrophils	1.8 ± 0.2	3.6 ± 0.1***	+100.0
Segmented neutrophils	32.0 ± 1.1	28.9 ± 0.5*	–9.7
Lymphocytes	59.9 ± 1.2	61.2 ± 0.9*	+2.2
Monocytes	3.7 ± 0.5	3.1 ± 0.9*	–16.2
Leukocyte intoxication index	0.63	0.79	+25.4

Note: *p < 0.05, **p < 0.01, **p < 0.001 compared with the control group

A decrease in erythrocyte count by 7.6% (26.9 ± 0.2 T/L) compared to 29.1 ± 0.1 T/L in the control group was also recorded. Reduced hemoglobin concentration and erythrocyte count indicate the development of anemia and chronic inflammatory processes in infected birds.

The leukocyte count increased by 13.0% and reached 36.5 ± 0.5 G/L compared to 32.3 ± 0.3 G/L in the control group. An increase in eosinophils by 50% also indicates the presence of an inflammatory process in turkeys with the chronic hepatic form of histomonosis.

The proportion of segmented neutrophils in healthy turkeys was 32.0 ± 1.1%, whereas in infected birds it decreased to 28.9 ± 0.5%, which was 9.7% lower (p < 0.05), indicating suppression of the immune response.

The leukocyte intoxication index (LII) in the control group of turkeys was 0.63 conventional units, whereas in birds with chronic histomonosis it reached 0.79 conventional units, representing an increase of 25.4%. However, compared to the acute course of the disease, this value was 15.1% lower.

Conclusions

1. Histomonosis in turkeys is accompanied by pronounced alterations in morphological blood parameters, the nature and intensity of which depend on the form and course of the disease. The acute course is characterized by the development of moderate anemia, pronounced leukocytosis, a left shift of the leukocyte formula, increased eosinophil counts, and elevated leukocyte intoxication index, indicating an active inflammatory process and a high level of endogenous intoxication.

2. In chronic histomonosis, more profound disturbances of the erythrocyte component of blood were observed, manifested by decreased hemoglobin levels and erythrocyte counts, indicating the development of anemia. At the same time, leukocytosis was less pronounced; however, eosinophilia, leukocyte formula shift, and increased leukocyte intoxication index persisted, reflecting a prolonged inflammatory process and immunological exhaustion of the organism.

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